PUPILS LEARNING MATHEMATICS: BELIEFS AND ATTITUDES

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In partial fulfilment of the requirements for the degree of Doctor of Philosophy, University of Surrey, 1988.
This study investigated whether pupils hold personal beliefs and attitudes which could affect their performance in mathematics lessons in such a way as to either facilitate or impede learning.

There were four parts to the study which took place over three years. In the first part, personal constructs about all school subjects were elicited from a group of pupils in their first year of comprehensive school. The interviews were recorded and provided background data for the study.

One year later, the same pupils were asked to rate eighteen mathematics topics on the constructs of like/dislike; easy/difficult and useful/not useful. The interviews were again recorded and used to develop categories of pupil beliefs. These were used to develop a number of questions which were later put to the same group.

Six weeks later the pupils divided into groups of three and took part in videorecorded problem solving sessions. This provided triangulated observational and oral data to corroborate or refute data from other parts of the study.

Finally, approximately one year later, each pupil was asked the questions developed from the second interview categories. These were posed in an open ended form and were also used to develop belief categories.

These final categories provided the information on which to compare the beliefs of the study group pupils. The basis for comparison was the pupils' mathematical setting and their positions in yearly examinations.

Data from across the study were used to provide case studies of three pupils.
The main conclusions were that beliefs and attitudes do affect mathematics performance, but that the effect was not the same for high and low settings; that problem solving ability correlated poorly with setting, and that for individuals it was necessary to examine a constellation of beliefs rather than any single ones.
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Chapter 1

AN ORIENTATION TO THE THESIS

Introduction

In this introductory chapter I shall first discuss the problem which led to this study and my reasons for selecting one particular approach rather than any other. Following that, I shall provide a brief outline of the contents of each chapter. In this way I will demonstrate the order in which the work was done.

1.1 Statement of the problem

Complaints about falling standards of mathematical knowledge in our school population are legion. This has been the case since long before there was compulsory education. Taken out of context, it can be very difficult to decide whether a speech made by some worthy or other about the need for improved standards was made this year, thirty years ago or at the turn of the century.

However, the belief about falling standards has always been accompanied by a belief that mathematics is a very difficult subject to master and that, except for basic arithmetical concepts, only the most able pupils will be able to cope with the subject. It is a circular argument which is not often examined. Certain pupils are said to be able to learn mathematics because they have a natural ability in the subject and the fact that they have a natural ability is demonstrated by their facility with the subject matter.
This view of mathematics as a difficult subject has become so entrenched that when the very influential Cockcroft Report (1981) suggested that the bottom forty per cent of pupils were capable of learning only the most basic mathematical facts there were very few voices heard in disagreement.

I did disagree. I did not, and do not, feel that the nature of mathematics is such that it can be successfully learned only by a limited proportion of the population. I believe that, just as being human implies having a facility for language, so being human implies having the potential for learning how to do mathematics. In other words I believe that mathematics results from the way we, as humans, organise our concepts and that this is something common to us all.

Teaching mathematics to pupils who belonged to the group labelled less able provided me with a further reason to disagree. By definition they were less able at mathematics but, as I got to know each new group, their behaviour and conversation convinced me that they might have just as much potential as did their more successful peers.

Whilst unsuitable teaching methods can be blamed for much of the general low level of pupil success in the learning of mathematics this cannot explain why some pupils succeed and others, with whom they have been taught for several years, fail.

Listening to pupils, the successful as well as the unsuccessful, I came to believe that pupils' beliefs, some of them general and some specifically related to mathematics, together with the attitudes towards mathematics which the beliefs engender, play an important part in any particular pupil's success or failure in the subject.

For some time I gave the matter the type of passing attention that one does to something which eats at the edge of one's consciousness. The Cockcroft report, followed by the
opportunity to give some time to research, had the effect of persuading me that I should give concentrated attention to the part which beliefs and attitudes play in success and failure at learning school mathematics.

My claim that mathematics arises from the way in which we organise our concepts suggests a constructivist approach and, indeed, 'constructive alternativism' as described by Kelly (1955) is my philosophical stance. Consequently this was the approach I decided to use for my study.

1.2 Outline of the work

As I have already indicated the chapters which follow mirror the way my study developed. It took place over a three year period and, apart from natural wastage, I used the same respondents on each of the four occasions on which I interviewed or observed them.

Chapter two is a survey of some of the literature on the subject of beliefs and attitudes as they relate to mathematics. Although most of the work to which I refer took place before I began my study I have included one item which was reported more recently as an example of the near exponential growth of research into the subject which is now taking place.

In chapter three I explain my methodology for each stage of the study. This was basically the same for three of the four stages although there were minor variations. However, because I chose to triangulate in order to obtain data from a different viewpoint, the third stage was different.

The first stage of the study involved interviewing pupils to obtain background data on their beliefs about all their school subjects and their attitudes towards school in general. The interviews were conducted indirectly in the
course of the elicitation of personal constructs about school subjects. In chapter four I discuss these interviews and say a little about my findings.

Chapter five deals with the next stage of my study when I interviewed the same pupils for the second time. Using methods similar to those used in the first interviews, I now talked to them about their beliefs about, and attitudes towards, mathematics. How I did this, and the results, are discussed in this chapter.

The next stage of my study, which I explain in chapter six, involved videorecording the pupils in groups of three as they worked at a number of problems. This was the stage at which I used triangulation to obtain observational and oral data concerning pupil behaviour. In this chapter I discuss the problems, the problem-solving sessions and my findings.

In chapter seven I discuss my final interviews with the pupils. At that stage I asked each one a number of questions which I had developed from categories identified from the data from the second interviews. The responses to these questions were used to develop categories on which I could compare pupils with one another. The interviews, questions, categories and outcomes are discussed in this chapter.

Having interviewed the pupils three times and observed them once I had a considerable amount of data for each one. Discussion of that data at a general level in chapters four, five and six meant that the richness of the individual data was lost; so, in chapter eight, I recreated it in the form of three case studies of pupils. Doing this also allowed me to bring together, at least for these three individuals, the data from across the studies.

In my final chapter, chapter nine, I summarise the stages and processes of my study and make suggestions for further work.
Chapter 2

BELIEFS ABOUT AND ATTITUDES TOWARDS MATHEMATICS: A SURVEY OF THE LITERATURE

Introduction

In my search for information about previous research in this area I first turned to recently published books whose titles indicated a general interest in the learning of mathematics. I imagined that in this way I would find some pointers in the right direction. I chose three books: The Psychology of Mathematics for Instruction by Resnick and Ford (1981); Children Learning Mathematics by Dickson, Brown and Gibson (1984) and Developing Mathematical Thinking edited by Ann Floyd (1981). It had seemed obvious to me that it would be necessary to take beliefs and attitudes into consideration in any discussion of the learning of mathematics and so I was amazed to discover that none of the above specifically addressed this topic.

When, a little later, I came across a book which was addressed specifically to parents and teachers and was entitled 'How Children Learn Mathematics' (Liebeck P.1984) I somehow still managed to be surprised by the lack of attention given to the topic. There was just one final paragraph saying that research has shown that a child's attitude to mathematics seems to be consolidated by the age of eleven and that, therefore, there is a need to maintain a positive attitude up until that point. I began to wonder if I was the only person concerned about the matter.
2.1 Research from the psychometric standpoint

Next I turned to the books, 'Critical Variables in Mathematics Education' (Begle E.G. 1979) and 'Research on the Social Context of Mathematics Education' (Bishop A.J. & Nickson M. 1983) and to review articles by Lewis Aiken (1970;1976) and by Laurie Reyes (1984) in the hope that these would provide me with information about specific research. They did, and I looked at much of that to which they referred, but I found very little which was of help to me. I shall give some quotes from Begle to indicate why this was so.

Begle was writing at the end of the seventies and was reviewing work reported for the period 1960 to 1976. He referred to Aiken's 1970 research and stated that the overlaps between his and Aiken's references were small because Aiken's referred mainly to earlier work. I report this because what I have to say about the work to which Begle referred applies equally to that referred to by Aiken in all three of his reviews which I have mentioned. In other words, the work which was of little relevance to me took place over a fairly long time span.

Begle devoted a chapter to 'Student Variables' and a subset of these he referred to as 'Affective Variables'. He wrote:

"The attitudes and feelings which students have about mathematics have been classified and studied under a number of different headings."

He then proceeded to divide the studies into:
- Anxiety [27 studies]
- Mathematics Attitudes [93 studies]
I initially imagined that two hundred and twenty nine pieces of work, together with the many more mentioned by the other authors I had referred to, would provide rich pickings. However I rapidly realised my error. Referring to Mathematics Attitudes Begle wrote:

"About half of these studies merely mentioned students' attitudes towards mathematics".

His general conclusions were that the average student attitude towards mathematics is a neutral one but that, on the whole, there is a slow decline in positive attitudes once pupils reach secondary age.

He then wrote that:

"The remaining studies are divided up about equally between investigations of the relationship between mathematics attitudes and mathematics achievement and investigations of procedures intended to improve student attitudes".

The findings here were mainly that there is a slight positive relationship between attitude and achievement but no way of knowing the direction of causality.

Turning to motivation Begle wrote:
"More than half the studies relate motivation to mathematics achievement. ... The rest of the studies investigate the levels of motivation in different sets of students or investigate procedures which might change motivation".

His general findings on personality, school attitudes, self-concept and test anxiety indicate that here too the stress was on investigating their relationships with achievement.

It made very depressing reading. My feelings were not improved when I read many of the articles. I had hoped to learn something about the attitudes and beliefs but all I found out was that the attitudes existed, something of the strength with which they existed and a little about the degree to which they correlated with mathematics achievement. I found out very little about beliefs.

As I went through the work I found myself comparing the situation to an imaginary one where a doctor is called to a child ill with some rash-producing sickness. The doctor comments on the fact that there is a rash of some sort but says nothing about whether it might be chicken pox, measles or some other ailment. He then pays great attention to the number of spots the child has and uses this as an indicator of how ill the child must be feeling. Finally he comments on the amount of itching which must be accompanying that particular number of spots and leaves the scene having contributed nothing to the parent's knowledge of what is wrong or how the sickness should be treated. I hasten to add that this analogy does not suggest that I see attitudes and beliefs as a form of sickness. I am simply comparing the diagnosis, or lack of it, with the research mentioned above.

As I indicated above, one of the main reservations I have
about the research Begle described was that, on the whole, it ignored beliefs. I had, perhaps naively, assumed that others would share my view that beliefs are the foundation stones of attitude. In fact I did not find a really clear discussion of the matter until some time later when McLeod (1987) attempted to clarify the use of terminology in the affective domain. Introducing the topic, he wrote:

"The affective domain is used here to refer to a wide range of feelings and moods that are generally regarded as something different from pure cognition. The main terms used to describe the affective domain are beliefs, attitudes and emotions. These terms vary from 'cold to hot' in the level of intensity of the feelings that they represent. They also vary in their stability; beliefs and attitudes are generally thought to be relatively stable and resistant to change, but emotional responses to mathematics may change rapidly".

He added, a little later:

"Sometimes researchers get involved in arguments about whether cognitive processing can be separated from affective processing. A similar argument exists about whether one dominates the other. In this paper I will assume that affect and cognition are inextricably linked and that we cannot separate the two".

Having established his views about the affective domain
in general McLeod then went on to define the terms: beliefs, attitudes and emotions. I shall refer here only to what he had to say about the first two of these. He began with beliefs, saying:

"Beliefs about mathematics generally involve very little affect, and are frequently based as much on cognitive responses as on feelings or affective responses. Beliefs about self may have more of an affective component, but in general beliefs will be viewed as primarily cognitive in nature".

Concerning attitude he wrote:

"Attitude toward mathematics is used to refer to feelings about mathematics that are relatively consistent. For example, attitude will be used to refer to how much students like mathematics, and to how confident they feel about doing mathematics. Attitudes may have a component that is a belief, but they are distinguished from beliefs by the feelings that accompany the beliefs".

I would, on the whole, agree with McLeod's clear definition but there are slight areas of disagreement between us. As I have already suggested above, I would argue that beliefs are the foundation stones of attitudes. I would also argue that attitudes arise when two or more beliefs interact in a fairly stable way. My disagreements with McLeod are minor and come about because my approach to this research has its basis in Personal Construct theory. I will not take the matter any further here because I will make my position clear
at the beginning of chapter three.

My other main reservation about the research discussed by these writers also arises from my theoretical stance. In all but a tiny minority of the studies referred to, those who were studied were asked to respond to questionnaire items, attitude scales or projective tests. Consequently, even if the studies had gone beyond discovering the existence of attitudes and the extent to which they correlated with achievement, and even if they had been looking at beliefs as well as attitudes, I would have entertained some doubts as to their value.

Fransella and Bannister (1977) discussed this in the following words:

"Traditionally, a psychological test is based on dimensions proposed by the psychologist, in terms of which the subject will be allotted a position. Thus, whether it be a questionnaire, a laboratory measure or a projective test, the subject's contributions are compounded into categories and scale positions, the subject cannot do what we allow him to do in conversation, propose his own terms.

"We approach our subjects convinced that they must be either 'introvert' or 'extrovert' and our test will be arbiter; they necessarily have some quantity of 'intelligence' and our test will determine how much; they are either highly conditionable or poorly conditionable and our experimental procedures will settle the issue; the most meaningful thing that can be said about them is whether they are psychotic.
or neurotic and our test will decide. Always our base and point of departure is the notion of the subject as an element to be allotted a place on our constructs. The subject is seen as an object".

It can be claimed that many of the studies I have referred to above are not as extreme as the picture painted here would suggest. But the fact is that the methods used do, however unintentionally, lead to subjects being treated as objects and they are, therefore, methods which are inimical, not only to Personal Construct theorists but also, in this particular field, to any researcher or reader who takes into account the view that learners are actively engaged in constructing their own knowledge of, and beliefs about, mathematics.

As my arguments and comments suggest, my criteria for giving serious consideration to a particular study are such as to greatly reduce the number of studies which I find relevant. There were a few that I found as I combed through the literature but not many came from either Bishop and Nickson's book or from the review article by Reyes.

In the former there were references to only three studies which touched on attitudes and beliefs and none of these were of specific relevance to research in mathematics. One, undertaken by Duckworth and Entwistle (1974), investigated the attitudes to nine school subjects of six hundred second year and fifth year grammar school pupils. They found that fifth form pupils rated mathematics seventh for interest and fourth for difficulty. Another study (Selkirk 1974) found that adverse attitudes still persist and continue to deteriorate even in those pupils who study the subject at A level. The third study (Nash 1973) attempted to identify how pupils tend to discriminate between different teacher
behaviours. In spite of the fact that it was not specifically related to mathematics, this particular study was of great interest to me because it was the first one that I had encountered which not only employed the repertory grid technique with school pupils but also elicited both the elements and the constructs from the pupils.

I found the Duckworth and Entwistle study particularly disappointing. Their paper was entitled, 'Attitudes to School Subjects: A Repertory Grid Technique' and I felt quite excited at the prospect of reading about research similar to my own intended approach. My disappointment was great when I discovered that this was yet another 'paper and pencil' study with both the elements and the constructs being provided by the researchers.

Only a limited number of the articles referred to by Reyes were of interest because the review was largely concerned with maths anxiety and gender differences and I had already decided to pay only limited attention to these two important but already well researched areas. Reyes also looked at confidence in learning mathematics, attribution of success and failure in mathematics and the perceived usefulness of mathematics.

Once again the studies looked at were largely concerned with relating certain attitudes to mathematics achievement while using response items provided by the researchers. Reyes continually stressed how little work had been done in natural conditions. She made a rather interesting comment about methodology. Referring to work on attribution responses she commented that:

"These data show that gender differences in attribution responses depend partly on the instrument used to measure attributions".

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This made me feel even more confident in the belief that I should be looking to find out what the pupils themselves had to say.

Before considering any specific pieces of work there is one more aspect of the studies on which I would like to comment. Earlier, I remarked that my criteria for giving serious consideration to a particular study are such as to greatly reduce the number of studies which I find relevant. The criteria to which I was referring are concerned with looking at beliefs as well as attitudes and at data actively created by respondents. But approaching data from a Personal Construct theory point of view also produces problems when one tries to interpret data collected for psychometric studies. I will discuss a review paper by Head (1981) to make my point.

Head was discussing 'Personality and the Learning of Mathematics'. He criticised the existent psychometric tests of personality on the grounds of their rigidity, their ability to supply information on only the limited range of prescribed factors and the fact that they are not linked to a developmental model but he argued that the evidence provided by them must be taken into account. One particular comment he made concerned the fact that Entwistle and Wilson (1977) found mathematics students to be the most syllabus-bound and the least syllabus-free. He discussed it in the following words:

"The characteristic of a syllabus-bound student is that he resents departure from a prescribed syllabus while a syllabus-free student welcomes opportunities to pursue tangential issues which catch his interest. How might we interpret this finding? More than any other subject, other than perhaps
philosophy, mathematics is self contained, with the tests of truth and validity having internal consistency, in contrast with the natural and social sciences and history which are concerned with describing events in the outside world".

Now this topic could provide a basis for bridging the psychometric and constructivist divide. It would be possible to discuss the concepts raised from both points of view and from the constructivist point of view it could be asked what reasons a particular mathematics student might have for thinking in this way. It might even be possible to do some comparative research on the subject.

The discussion of such things as cognitive bias, divergent thinking and obedience could also be discussed in this way. However, when, as it is in Head's paper, the discussion is related to such matters as extrovert boys and introvert girls, and stable and neurotic pupils then there is no point of contact. Just as the notion of personal constructs has little meaning for the psychometrist so the notion of stable personality traits has little meaning for the constructivist and the research undertaken by those of one persuasion has little meaning for those from the other. And this is a further reason why much of the research into attitudes and beliefs in mathematics has proved not to be relevant to my particular study.

2.2 One detailed example from the psychometric literature

In my attempt to explain why I find most studies of little use for my present needs I fear I have painted a totally negative picture. In fact, it is unlikely that any piece of
research is without flaws and there is always some evidence which can be gleaned from most data. I have, therefore, decided to examine in greater depth, one review of psychometric research which looks at the role of attitudes in learning mathematics.

I have chosen a review rather than individual pieces of research because, unlike the latter, the former takes a wider view. And I have chosen this particular review to represent the field because the author has taken a definite interpretive stance.

In the late 1960's there was an American study by Neale (1969) which sought to examine two beliefs:

"a) that 'certain attitudes toward or beliefs about mathematics are thought to be important objectives of instruction', and b) 'that positive attitudes toward mathematics is thought to play an important role in causing students to learn mathematics'".

Neale quoted the International Study of Achievement in Mathematics (Husen, 1967) and said that it contained several attitudes that are considered to be desirable objectives of mathematics instruction. I quote:

"One, for example, was called 'attitudes towards mathematics as a process.' A low score on this scale indicates a view of mathematics as a fixed, formal system, which is learned by mastering rigid, unchanging rules. A high score represents a view of mathematics as something that is developing, allows for different approaches to problems, and requires understanding of phenomena"
rather than the application of rules.

"A second measure was 'attitudes about the difficulty of learning mathematics.' A low score indicates a belief that mathematics is only for an elite few; a high score indicates a belief that mathematics can be learned by anyone.

"A third example is 'attitudes towards the place of mathematics in society,' a scale which ranges from the view that mathematics is a luxury to a view that mathematics is essential to national development and that a society's ablest members should be encouraged to be mathematicians".

Neale tells us that the data from the International Study indicated that such attitudes appear to be independent of mathematics achievement. Contrary to expectations, there was no strong correlation between scoring high on these attitudinal dimensions and scoring high on achievement tests. And equally notable is the fact that there was shown to be a negative correlation between achievement and attitudes towards process and difficulty. This suggests that many pupils who are high on achievement may have a somewhat negative view of the subject.

Turning to the belief that a positive attitude towards mathematics plays an important role in causing students to learn the subject Neale discussed the components of such an attitude. It included:

"...a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activity, a belief that one is good or bad at
He examined a number of studies which had been undertaken in this area and concluded that, despite a widespread conviction that this attitude is important in causing students to learn or not to learn mathematics, there was no strong evidence to confirm that it is so.

What Neale did find was that the part played by such attitudes in causing students to learn mathematics is minimal and that, as they go through school, students tend to develop increasingly unfavourable attitudes towards mathematics. Discussing these, he pointed out that although, where it does occur, it is possible that favourable attitude causes learning it is also possible that learning causes favourable attitude and even that some third factor influences both attitude and achievement.

He then quoted research by Cattell and Butcher (1968) which purported to look at mental abilities, personality traits, and motivational factors and the findings of which indicated that attitude accounted for approximately twenty five per cent of variation in achievement.

But, for Neale, the particularly interesting finding from the study was that, in the correlation between attitude factors and achievement, the two factors with the strongest relationship were submissiveness and superego. He also noted that curiosity had a negative relationship with achievement. He concluded that:

"What makes Sammy learn is not so much that he enjoys discovering the orderliness of mathematical relationships but rather that he wants to be an obedient person and do his duty."
As evidence for this belief Neale quoted observations by Jackson (1968) which suggest that the hidden curriculum of the school:

"requires that children cultivate as primary virtues patience, compliance, and obedience."

He went on to suggest that:

"certain characteristics of the school as an institution overpower the influences of attitude toward learning".

I would suggest that this could be phrased in another way by saying that certain characteristics of the school as an institution help pupils to develop the belief that, in the context of school, one should be patient, compliant and obedient.

2.3 Earlier research from a constructivist standpoint

I will now discuss four articles which I encountered on my journey through the literature before deciding on my specific methodology. Three are examples of research and the other is a discussion article which refers to other research.

Mitchelmore (1980) examined differences in the ability of children in three different cultures to create three-dimensional geometric drawings. He used three locations: Columbus, Ohio in the U.S.A., Bristol, England and Kingston, Jamaica. In each location he used two primary schools and two secondary schools and from each school he worked with four boys and four girls from two different age groups. He therefore had sixty four boys and girls from four different
age groups in each location. Their ages were approximately eight, ten, twelve and fourteen. In each location pupils were selected from the middle of the ability range.

The pupils were shown solids of five different shapes and asked to draw them so as to make them 'look solid, like a photograph.' There were considerable differences in their ability. As Mitchelmore puts it:

"In other words, the average Bristol student was 3.0 years ahead of his Columbus peer, who was in turn 1.7 years ahead of the average Kingston student".

Mitchelmore discussed the likelihood that the explanation for the observed differences between the English and the American pupils may lie in the school mathematics curriculum. He said:

"In the author's experience as a student at schools and universities in Bristol and Columbus, English teachers tend to have a more informal approach to geometry, to use more manipulative materials in teaching arithmetic at the elementary level, and to use diagrams more freely in mathematics at both secondary and tertiary levels".

But he argues that this is not a sufficient explanation because otherwise one would have expected the difference to increase with the older children and it did not. He goes on to say:

"It seems more reasonable to suppose that the geometrical content of a country's school
Curriculum reflects the country’s general attitude towards the use of spatial models in thinking, and that it is a difference in this general attitude between the U.S. and England which was responsible for the higher spatial ability of Bristol children. For example, English infants may be given more constructional toys and American infants more working models”.

Turning to the explanation of the even greater gap in the ability of Kingston children Mitchelmore argued:

"The primary school mathematics system is almost entirely arithmetic-oriented; and although most of the secondary schools use textbooks published in England, the visual content is generally found difficult and is omitted. Manipulative materials are not often used in mathematics teaching, especially at the primary level”.

But again Mitchelmore looked further. He said:

"There is also some evidence of a lack of interest in spatial relations among the adult population. Jamaican newspapers contain many photographs but few diagrams (either graphs or 3D drawings). The fine arts are valued, but faithful 3D representation is not emphasised. Traditional attitudes to education, dating back to the years following Emancipation, reject practical subjects in favour of ‘book learning’. ...When all these
educational and cultural factors are taken into account, it is surprising that the differences in spatial ability between the Kingston sample and the Bristol and Columbus samples are not greater".

I have referred to this research in some detail for three reasons. Firstly, because it demonstrates so neatly that beliefs and attitudes can be accessed in more than one way. Secondly because it draws attention to the fact that individual beliefs and attitudes can, and often will, have their source in the larger community. In this study whole countries were compared but often the influence will be more local or will even reside within the extended family of one particular pupil. My third reason is to draw attention to the fact that the pupils' attitudes which matter are not only mathematics ones.

Woodrow (1984) discussed this problem in the context of methods of instruction. He argued:

"As it is currently taught mathematics in schools demands concentration, self-discipline, accuracy, conforming to rules, quietness, tenacity, precise and sophisticated language. Could not mathematics be taught so as to encourage creativity, group cohesiveness, intuition, expressiveness, extraversion. We often choose to teach mathematics in a manner which makes these characteristics disadvantageous in the mathematics classroom even though at later stages of mathematical education they may become valuable attributes. Mathematics in this way discriminates towards certain
personality traits and these are in turn often strongly culturally influenced. The authoritarian, self disciplined, group dependent and individuality suppressed nature of some Moslem societies already creates attitudes sympathetic to mathematics teaching. The more restive exuberance of some Caribbean pupils, particularly those with Jamaican ancestry, is less supportive of current approaches to mathematics learning. The differing demands of 'crafty cockneys' and 'dour northerners' present similar problems".

I would take issue, particularly in the light of Mitchelmore's research, with Woodrow's stereotyping. I would also disagree with him in his tendency to see these things as personality traits rather than examples from belief systems. However, I would totally agree with him in the way that he was trying to press for more concern over attitudes. He said:

"The effects on cognitive processes of the affective domain is an undervalued and under-researched area of mathematics".

I would endorse that.

Hoyle's (1982) study was concerned with the pupil's view of mathematics learning. She said:

"The research set out to examine how 14-year-old pupils perceived good and bad experiences associated with their learning in school, how and why they judged specific learning situations as good or bad and what
they perceived to influence these judgments. An attempt was made to 'capture' these perceptions by asking the pupils to tell stories about times during which they had felt particularly good or particularly bad when learning. The research also aimed to discover how frequently stories about mathematics, good or bad, might be told and to find out if these mathematics stories had any distinctive features in a comparison with stories about other areas”.

In discussing her results Hoyle said:

"Pupils were much more concerned with their own role in relation to learning mathematics than learning other subjects. Pupils had strong ideas about what they were capable of doing and what they were capable of understanding in mathematics and their mathematical experiences were dominated by this focus on self and feelings about oneself. ...The stories also showed that anxiety, feelings of inadequacy and feelings of shame were quite common features of bad experiences in learning mathematics. ...There was some indication that pupils in mathematics were particularly fearful and resentful of teachers who seemed to impose additional demands on them. ...Pupils were extremely concerned with the outcome of their work, they wanted to 'do it', 'finish it' and 'get it right'. ...Pupils appeared to demand grades and assessment yet seemed to see these
as 'information' as to their mathematical ability and therefore judged themselves highly if they did well in mathematics but found it difficult to rationalise any failure in the subject. ...Pupils did not talk about what their mathematics was about, or how it may be used. They did not appear to see that the subject could be of any interest in itself but only as something to be done, something to be mastered, something with an existence of its own".

It can be argued that in using this approach and asking pupils to talk about good or bad learning experiences Hoyle was asking pupils to concentrate on the extremes, with the consequence that the descriptions might be more emotionally charged than would otherwise be the case. This is a problem but it pales into insignificance when one compares the rich data which emerged from this study with the type of data which is generated by the traditional 'paper and pencil' approach. Nevertheless, it is a problem which must be kept in mind.

Of course Hoyle did not set out to provide widely generalisable empirical results. In her own words she said of the research, "Rather it hoped that the stories and their analysis would strike chords of recognition or stimulate insights in the reader and by this means be of value in teaching". I find these words pleasing. It is only too often forgotten that research is just as important when it informs practice as when it changes it.

Kiryluk (1980) did use a questionnaire about mathematics with her sample of six hundred and forty four pupils from five comprehensive schools in Oxfordshire. However they were open ended questions and thus did allow pupils to express
their own views within certain limits. The questions were:

- Maths is interesting when:-
- Maths is boring when:-
- I could do better in maths if:-
- A good maths teacher is one who:-

Discussing her findings Kiryluk said:

"Perhaps, not surprisingly, whether a pupil found mathematics interesting or boring, liked or disliked it, often depended on his or her understanding of the subject. The teacher, and in particular the ability of the teacher to explain well, were of paramount importance. Many pupils expressed very similar feelings. On the other hand, opposite points of view were also to be found. For example, many liked mathematics when it was easy, but a minority preferred solving difficult problems. ...Many pupils felt they could do better if their teacher explained more clearly, but this was not the only suggestion, although it was one of the most common ones. ...Their ideal teacher seems to be one who explains well, does not shout and does not spend too long on one subject. ...By far the least popular teacher behaviour was that of shouting. Where this occurred, it was mentioned by about half the class and very strongly disapproved of. ...Mathematics was viewed as an important and useful subject by the majority of the sample (although there were some who had their doubts). In fact, its
importance sometimes seemed to be overestimated”.

Of course criticisms can be made of this research. Pupils were limited by the nature of the questions. We don’t, for example, know how many of the pupils would have discussed the teacher if their beliefs and attitudes on the matter had not been specifically invited. However I would argue that even though the use of open ended questions is still limiting this is still a more useful approach than is the use of closed, given items. Certainly the responses which Kiryluk relates are very varied. Furthermore, together with the work by Hoyle, it demonstrates what rich data can be obtained when pupils are asked for their own beliefs rather than being asked to endorse the beliefs of others.

At this point I felt I had collected together enough information about the state of the art in research concerning beliefs about and attitudes towards the learning of mathematics for me to be confident that more knowledge was needed, particularly about beliefs, and that it could be best acquired by using indirect means such as had been used by Mitchelmore or Hoyle.

I had also discovered that there seemed to be no research at all into the particular area in which I was interested. I wanted to know if the beliefs and attitudes which pupils brought with them to their mathematics lessons influenced their performance. Furthermore if they did influence performance I wanted to know, for individual pupils as well as collections of pupils, which ones were helpful and which unhelpful. It seemed to me that the best way to find this out was to study a closely related group of pupils in one school as they moved from primary to secondary school and on through the secondary school and to use a variety of indirect methods.
to access their beliefs. What follows is a description and an explanation of that study.

2.4 Recent research from a constructivist standpoint

Before leaving the discussion of the literature I would like to refer to a study which has taken place since I began this work and which has encouraged me in my efforts. It is a study which takes a constructivist approach and I have selected it from a great number of possible references. It indicates what has been happening more recently in the area of research into beliefs about mathematics but it also says something about what had been happening in the seventies.

As everything I have written up until now in this chapter suggests, prior to 1984 there appeared to be very little indication in the literature that researchers of a constructivist persuasion were paying attention to the effects of beliefs and attitudes on the learning of mathematics. Since that time the growth in the number of reports has been extraordinary. It was as if I had set off on a lone journey to strange, exotic climes only to find, at the first port of call, that I had been joined by hordes of tourists. And, in the way that I might have felt under those circumstances, I did not know whether to be pleased or sorry. Certainly I have experienced first hand the meaning of zeitgeist although I am sure that the fact that I became involved in the sudden surge of interest was quite accidental. I had, for some time, been too involved in the day to day matters of teaching mathematics to be concerned about happenings in the research community.

The first work that I came across was by Paul Cobb (1985) and from it I learned not only that studies were taking place but that there had been a few in the seventies and early
eighties which I had not discovered. In particular there was the case study by Erlwanger (1973) of a boy called Benny which had alerted the mathematics community to the need to consider children's beliefs about the nature of mathematics. This was followed by a spate of other studies.

The reason why I had missed Erlwanger's study and later ones was because I was looking specifically for research into beliefs and attitudes but the discoveries which were being made were arising mainly from studies into problem solving behaviour. This is no excuse for my having missed the work but at least now I was alerted to it.

As part of a two-year teaching experiment, Cobb had been looking at the problem solving activities of six first grade children. In the article to which I refer he wrote about the anticipations and expectations of two of the children, Scenetra and Tyrone.

There were a number of interesting findings. For instance it was noticed that Scenetra, in an exercise where she was required to move marbles from one of two cups to the other, came to rely solely on a superficial number word sequence to work out the next answer. In other words, it was her belief that to solve the task she should focus on number words and numerals. Tyrone, on the other hand, did not think to do this. According to Cobb his approach arose because of his belief that he could create meaning by structuring experience in terms of his arithmetical concepts. He anticipated that he would be able to solve the task by constructing relationships between numbers.

Another example given by Cobb concerned Scenetra's behaviour when it would have been possible for her to use previous answers to help in finding the next answer. She strove to give the appearance that she was solving each problem independently of her previous solution. Cobb suggested that this behaviour did not reflect inadequacies in
her mathematical knowledge but came about because of her beliefs about the legitimacy of certain methods.

In his conclusions Cobb suggested that the children's expectations and anticipations about the sort of experiences they would have in mathematical situations were constrained by their implicit and explicit beliefs about mathematics. He also suggested that these beliefs constrained the sorts of implicit and explicit heuristics the children employed.

Finally Cobb suggested that children's beliefs about mathematics may be related to their motivations for engaging in mathematical activity. He said:

"Scenetra's ego-involvement was compatible with her focus on ends rather than means and her belief that mathematical knowledge was primarily instrumental in quality. Tyrone, a task-involved child, strove to achieve relational rather than instrumental understanding".

I have discussed this later study partly to let it be known that there was constructivist work afoot before I began my study; partly to demonstrate yet another useful method for accessing beliefs about mathematics; but mostly to provide corroboration for my ideas about the best general approach to research into the subject.
Chapter 3

METHODOLOGY OF THE STUDY

Introduction

In my approach to this study I have taken the position of 'constructive alternativism' as described by Kelly (1955). The implication of Kelly's theory is that people, in order to understand themselves and the surroundings in which they 'live, work and play', and in order to anticipate future events, construct tentative models of the world and evaluate these models by reference to their own personal criteria. These criteria are the hypotheses or constructs which individuals build up as they test their models of reality and find them useful or wanting and therefore in need of change.

It is important to note that this constructivist view rejects an absolutist notion of truth. Individuals who are making sense of events out of their own experience are inevitably creating their own version of truth. This is not to suggest that there will be no community of beliefs. Shared experiences and shared cultural background lead to the overlapping of individual interpretations of events but this still allows for individual differences. It is such differences and similarities in attitudes towards, and beliefs about, mathematics that I have been attempting to capture.

My approach is that of constructive alternativism because that is my own philosophical stance but it has two sorts of implication for my research. The first has to do with the methodology I chose to use in my work and I will deal with that in a moment. The second has to do with the subject matter of my study: the beliefs and attitudes which pupils
bring with them to their mathematics lessons and the way those beliefs and attitudes affect their progress in school mathematics.

I am faced with a problem of terminology. Beliefs and constructs, I would argue, are one and the same thing. Thus, if a pupil says that mathematics is a difficult subject, one researcher might refer to this as a belief and another as a construct but while the words are different the meaning is, I suggest, the same. But the term 'belief' is one which is much more widely used in both the research community and the world at large. Its use also has a much longer history than the use of the term 'construct'. Consequently, I will use the word 'belief' throughout this work but I would remind the reader that I am using it to convey the same meaning as I do when I use the word 'construct' elsewhere in this work (e.g. chapter four) when discussing Personal Construct theory.

In the same way, although this is perhaps a more controversial view, I would argue that attitudes are comparable to the systems of constructs described by Kelly (1969). In the introduction to chapter two I said that I disagreed slightly with McLeod's (1987) argument but that I would explain my position in chapter three and this is what I am now attempting to do.

Having said, "Beliefs about mathematics generally involve very little affect, and are frequently based as much on cognitive responses as on feelings or affective responses" McLeod, in discussing attitudes said that they, "...may have a component that is a belief but they are distinguished from beliefs by the feelings that accompany the beliefs". Kelly (1955) argued that a construct embodies both emotional and intellectual (i.e. cognitive) aspects and, from this point of view, there is no value in attempting to tease the two apart. I would suggest that attitudes can usefully be regarded as higher order constructs formed as a number of beliefs.
(constructs) organise themselves into a system. However, since the term 'attitude' is, like the term 'belief', common currency among researchers and general public alike this is the word which I will use throughout this work.

3.1 Research methodology

3.1.1 For collection of the data

I chose to use the Repertory Grid technique developed by Kelly and by others since Kelly (Fransella and Bannister 1977). Although personal philosophy was influential here there was also a pragmatic reason for the choice. For reasons which I gave in my introduction to chapter two, I did not wish to use any of the methods to which I referred at that time. A possible alternative would have been the use of interviews with semi-structured or open-ended questions but I would still have been faced with the problem of determining which questions to ask. The Repertory Grid technique is one which allowed me to learn something about the pupils' own beliefs and attitudes rather than providing me with their answers to questions about what I, or others, thought those beliefs and attitudes might be.

Later in this chapter I will briefly discuss the actual methodology involved when I discuss the first interviews but I will leave more detailed discussion to chapter four, where I will discuss the first interviews, and to chapter five, where I will discuss the second interviews where I used a modified version of the Repertory Grid technique.

For the third interviews I did use verbal questions but I justify that on the basis that they were questions derived from the categories which I developed out of what the pupils had to say in the first and second interviews.
I did use one other method of gathering data. I asked the pupils to solve problems in small groups of three and I videorecorded each of the sessions. Broadly speaking my purpose was to use triangulation methods to create more varied data about the pupils.

Although I will discuss the matter further below, for the sake of clarity I would like to point out that I did not confine myself to the construct data. I audiorecorded, and used for analysis, all the conversational material from the interviews.

3.1.2 For analysis of the data

As I will explain in more detail below when I discuss the first interviews I used the Repertory Grid technique mainly as a vehicle for non-directive questioning and I had therefore to choose, before collecting the data, a method for analysing it once it had been acquired.

The most suitable method, and the one I used throughout the study, seemed to be that which is generally used with the Grounded Theory approach (Stern 1980). I trust that my description of the method, and how I used it, will itself provide adequate explanation of why I chose it in the first place.

Once I had transcribed the data I examined it, line by line, to identify statements which indicated a belief or attitude held by the pupil who had made the statement. An example from my data is from a pupil who said, about copying other people’s work, “If I’m in trouble I would. If I want to get out at break time”. This suggests that he believes it to be legitimate to copy in order to avoid an unpleasant experience.

Having drawn out all the belief and attitude statements
made by each individual pupil during any one interview I then compared all the statements to identify those which were similar enough to be placed in the same category. For example there were other pupils who made statements using different words to those used in the example I have just given but where the words implied the same, or similar beliefs. Because of slight differences among them I finally categorised all such statements as, 'willing to copy to achieve personal ends unconnected to mathematics'. A rather long-winded label but one which, I trust, conveys my meaning.

The categories which I developed thus became the units of data which I used to compare pupils with each other. I also used them as a starting point for the collection of data in later interviews. I will explain how I did this in chapters five, six and seven because it will then be possible to explain my methods in context.

3.2 The first interviews

Although I was concerned with pupils' attitudes towards mathematics I felt that it was important to first of all learn something about their attitudes to all subjects, and to school in general, in order to have a context in which to consider beliefs about mathematics. The first interviews were, therefore, directed towards this end.

For the reasons I have just discussed when talking about data collection I decided to use the Repertory Grid technique which is not only a method of collecting data which is in keeping with the constructivist approach but is also a method which is particularly relevant to Personal Construct theory. After selection of the elements the interviewer, in this case myself, presents them in all possible triadic combinations to the interviewees and asks them to indicate some way in which
two of the elements are the same and the third one is different. The response, which is referred to as a construct, is recorded on a grid with that part of the construct which refers to the two elements being written at the left hand side of the paper and the part which is about the third element on the right hand side. Once the construct is recorded the interviewee is asked to give ratings, ranging from one to five, on that construct for each of the elements. The ratings are also recorded on the grid. The rest of the interview follows the same pattern.

At this stage I have provided only this brief outline because I think it will be more informative to describe the Repertory Grid technique procedure in detail in chapter four when I discuss the actual interviews.

Constructs, however they are collected, are most useful in a dynamic situation where analysis is to be undertaken very soon after data collection and the results are to be discussed with the interviewee within a relatively short space of time. They are not, on their own, suitable in a static situation where the constructs are simply being used as data.

In this particular instance the collection of constructs was used as a vehicle for non-directive questioning. They were recorded and analysed but the conversation in which the selection of constructs was embedded was of far greater importance for the purpose of this study. To that end, and with the pupils' permission, the conversations were recorded and later analysed. This is a standard use of the method. To avoid repetition I will say here that all three interviews were recorded and analysed using the methodology which I discussed in 3.1 above.

The interviews took place during March of the study group's first year in the school. They are discussed in chapter four. The elements used can be seen in Appendix B.
3.3 The second interviews

At the same time that the pupils were providing constructs in the first interviews their conversations were also providing me with very general information about their home and school backgrounds and their attitudes towards, and beliefs about, most of their school subjects including mathematics. I now wanted to narrow the area of study to a discussion of attitudes towards and beliefs about mathematics.

I had initially planned to use the same Repertory Grid method for the second interviews as I had used for the first ones. However, once I had selected the elements I became somewhat concerned as to whether or not the pupils would find the comparison too difficult. I ran a pilot study and, as I will discuss in detail in chapter five, I discovered that my fears were well founded.

As a result of this pilot study I decided that the best alternative method would be to talk to the students about their attitudes towards mathematics using printed examples of mathematical topics as focal points for discussion. A second pilot study demonstrated how difficult it is to be non-directive in such circumstances. It also indicated that pupils found the method somewhat threatening because they felt they were being tested.

I will not discuss this pilot study or its outcome in any detail until chapter five and the same applies to the approach which I finally decided to use. It was still within the constructivist framework and was based on a similar method of collecting personal constructs. I ran a third pilot study to test this method and then used it with the study group. The elements used in the second pilot study, and those used in the third pilot study and the actual interviews, are shown in Appendix C1 and C2 respectively.

The pilot studies took place in the Autumn and Spring
terms of the pupils' second year in the school after the analysis of the first interviews had taken place. The interviews with the study group took place in May of the second year. They are discussed in Chapter five together with the data which they produced. That part of the data which arose from the rating of constructs was purely quantitative but that which arose from discussion of the constructs was mainly qualitative. However, the latter also led to a certain amount of quantitative material. The statistical information from the data is shown in Appendix D Tables 1 to 8.

3.4 The problem-solving sessions

I gained much useful information from the second interviews but I felt some concern about the elements I had selected as a basis for the discussion. Because they were the topics pupils covered in school mathematics this meant that the school's or, arguably, the examination board's concept of 'doing mathematics,' rather than that of the pupils, was being used as a basis for this part of the enquiry. To find out if this created bias or distortion in the data I decided to include problem-solving sessions as a way of obtaining behavioural data. It turned out to be a wise move. I will discuss all of this and the methodology of the problem solving sessions in detail in chapter six. The questions I asked are shown in Appendix E.

I would just like to add that a further reason for asking the study group to take part in problem-solving sessions was in order to corroborate or refute my observations and interpretations from the earlier part of the study and in the hope that it would provide deeper insights into their attitudes to, and beliefs about, learning mathematics. In chapter six I will try to show that it served this purpose.
In the same way as in the first two interviews the information from these problem-solving sessions was used to provide both qualitative and quantitative data. The latter came from the answers the pupils gave to the problems and the former from the pupils' discussions and behaviour. The sessions took place in July of the second year and, as I have implied, they are discussed in chapter six.

3.5 The third interviews

The third interviews were the main part of the study and they consisted of a series of questions which had been developed from the categories produced by the pupils in the first and second interviews. I asked the same forty four questions of each pupil but, in each case, the response I received led to further open ended questions.

Apart from the use of given questions, my methodology in these third interviews was very much the same as that which I used in the first and second interviews. I will not discuss this in detail until chapter seven. The questions, and the categories which I derived from the responses given by the pupils, are shown in Appendix F1. The reasons for the way the questions are grouped will also be discussed in chapter seven. The Tables in Appendix F provide information concerning the categories to which individual pupils subscribed.

I also used the third interviews as an opportunity to discuss, with each pupil, the conclusions I had drawn about them as a result of analysis of the first and second interviews and the videorecorded problem-solving sessions. I felt that their views on my interpretations were as important as my own. I wanted them to be able to tell me if they thought I was wrong and let me know if I had been right at
the time but the situation had changed.

3.6 Case studies

The second interviews and the problem-solving sessions provided both qualitative and quantitative data. Qualitative data from the first and second interviews and, to a lesser extent, from the problem-solving sessions provided the basis from which the questions were developed for the third and final interview. Here again the method used produced both quantitative and qualitative data.

Consequently, considered from one point of view, the first and second interviews can be seen as exploratory studies which provided data for developing the questions for the third interview. The problem-solving sessions can be seen as a check on data from the second interviews and any numerical data from the first three sessions would be serendipitous.

This approach to looking at the data is valid and useful as it stands. Looking for combinations of attitudes and of beliefs, or for a mixture of the two, which appear to be associated with success or failure in mathematics is what I set out to do. However in making comparisons one inevitably simplifies. And in this case simplification was bound to lead to the loss of information about the rich tapestry of interactions between the different beliefs which each pupil brought to mathematics. By including case studies I hope to overcome this loss.

Furthermore, I feel confident that the use of case studies will more clearly show the development of the study through each of its stages. This was my original reason for deciding, from the start of the study, to include them. The case studies will be presented in chapter eight.
3.7 Events leading up to the interviews and problem-solving sessions

3.7.1 Sampling reasons for the choice of school

In planning this study I gave thought, at an early stage, to the choice of sample. Once I had decided to look at pupils who had newly moved to secondary education I had chosen my total population but the question of how representative of that population the sample would be was still open. Should I choose on the basis of apparent ability as measured by psychometric tests or on the basis of socio-economic factors? Ought I to consider the type of mathematical education provided in different schools or even whether or not the pupils were set or in mixed ability groups for their maths lessons?

In the event, I decided to ignore the matter of setting and the type of mathematical education. I was concerned with the attitudes and beliefs of the pupils; although these could be affected and, quite probably, changed by factors related to the schools they attended I concluded for reasons which I will now explain that it would be more useful, for the purpose of this study, to sample on the basis of apparent ability and socio-economic background.

In spite of the general progress towards the problem-solving orientation of the G.C.S.E. curriculum in most schools, progress in that direction has tended to be slower in mathematics. In fact schools have been given longer in which to implement changes in the mathematics curriculum than they have for other subjects. Consequently there are still many schools using teaching methods in mathematics which have been in use for at least the last two generations. Similarly many schools still place their pupils in ability sets for mathematics. These facts helped me in my decision to ignore
teaching methods and setting in such a small-scale study.

The use of different teaching methods and the fact of being set or taught in mixed ability groups could affect the attitudes of pupils towards learning mathematics and even their beliefs about what it means to be doing mathematics and their own role in that process. But perhaps more relevant is the possibility that, in the absence of external pressure for change, it will be the more enthusiastic groups of teachers who will organise their departments into mixed ability sets and devise ways of encouraging a problem-solving approach to mathematics. If that is the case then their enthusiasm itself may more overtly convey to the pupils the teachers' own attitudes and beliefs than would be the case in more conventional classrooms. This, in turn, could be expected to affect the attitudes and beliefs of the pupils.

These arguments further encouraged me in my decision to ignore teaching methods and setting. I felt that I would have been unable to make comparisons across the study group had I not done so. The fact that it makes it impossible to generalise across schools is not relevant because it is a characteristic of naturalistic enquiry that its "thick description" (Guba and Lincoln 1985) makes clear the type of population to which a study might apply.

The decision to limit the study to age, apparent ability, and socio-economic factors, meant that I was able to use one tutor group in one school as my sample source. Before explaining why this was so there is one point that must be made clear. My reference to socio-economic factors is not based on individual assessments but on catchment areas or type of school. Had I chosen to use an independent school for my sample source then I could have been fairly sure that at least the vast majority of the pupils would have been from a high socio-economic background. Had I chosen from certain inner city schools the opposite would have been the case.
From the point of view of socio-economic grouping the school I chose was highly suitable. It was in an educational area where the state secondary schools were all comprehensive. Furthermore the catchment area for the school - consisting of one largely working class town, one rather smaller, mostly middle class town and a number of villages - ensured a good social mix in the school.

The school was also highly suitable in that it was quite easy to obtain a sample with an across-the-board range of ability. This was because of the school's policy, since its inception, for placing pupils into tutor groups as they join the school. Psychometric tests taken in junior school are used, together with progress reports, as a basis for attempting to ensure that the ability range in each tutor group reflects the ability range of the total yearly intake of approximately three hundred and sixty pupils.

3.7.2 Other reasons for the choice of school

A further reason for choosing this particular school was its use of tutor groups. These are social groupings in that throughout their time in the school the pupils meet with the same people at the beginning of each morning and afternoon. In this school, during the earlier years, the members of a tutor group have many of their lessons together. Gradually they move into sets for most subjects but the tutor group and the particular house to which that tutor group belongs remain a focal point for the social and pastoral side of their education. Consequently a tutor group in this particular school, as well as providing a sample of pupils with a wide range of abilities, gave a stable base for a study which was to take place over time.

My final reasons for the choice of school are more
personal while still being relevant to the study. I needed access to the school over a considerable period of time. Also, since I would be spending so much time there, good relations were important. Both of these were facilitated by my choice of a school where I had taught for a number of years and where I was, therefore, well known to the staff and to my previous pupils. This could have been a disadvantage had I been studying members of staff or pupils who were known to me but as my concern was entirely with pupils who were new to the school it did not present a problem.

Also, and again because of the length of time I would be visiting the school, there was the problem of access to pupils and to rooms. My knowledge of the organisation of the school made it simple for me to organise my own access to rooms and my familiarity with time-tabling procedures meant that I could arrange to see pupils at times that would not unduly inconvenience either them or members of staff.

3.7.3 Approach to headmaster and group tutor

Section 3.7.2 will have indicated that my problems in this area were fewer than those experienced by many researchers when they work in schools. In this case my method of approach to the headmaster was to give him a copy of my protocol for the research study and ask if he would allow me to use his school for the collection of data. He read the protocol and agreed to let me go ahead.

As an added bonus a teacher who was very interested in my proposed research was about to become group tutor to a new intake. Using his group as a study group meant that suspicion and doubt among the pupils could be reduced by his reassurances as well as by my own activities. This is one
more reason why my problems were probably less than is normal.

3.7.4 Approaches to parents and pupils, and later contacts

I sent letters to parents requesting permission to interview their children (See Appendix A). As can be seen from this copy, I asked parents to indicate if they would be willing to be interviewed themselves. Unfortunately time was not available for this but the fact that more than two thirds of the parents were willing to be interviewed is, I suggest, indicative of the important part that parents believe mathematics to play in the lives of their children. I hope that such interviews may take place after this particular study has been completed at which time I will discuss my findings with any parents who demonstrate an interest. I would imagine that any parent who would be willing to give up their time in this way might well be interested in learning something about the work.

I spoke to the pupils on two occasions before the study began. During their first two years in the school they have one period of an hour and ten minutes each week as a tutor group period. The group tutor made two of these periods available to me.

On the first occasion I explained the nature of my research and stressed the fact that, as far as they were concerned, participation was optional. I also stressed that the research was to be a cooperative affair. In other words, I was not going to be doing something to them; we were going to be embarking on a joint venture. I made every effort to live up to this promise.

The second hour was spent discussing the nature of Repertory Grids, how they would be elicited and what I would
and would not be doing during the interviews. As a group we worked out some constructs and by the end of the session I felt that they all had a fairly clear view of what my research was about.

At this point I made it clear that they were not being tested and that the information I received from them would not be shared with members of staff or published in a way that would identify them. I also explained why I wanted to make audiorecordings of the interviews and asked their permission to do so.

At the end of this second session I arranged times for interviews to suit individual pupils. All the pupils but one were eager to join the study. That pupil later asked if he could join in, and I agreed.

I kept in touch with the group between the first and second interviews by paying occasional visits to the school during their tutor group periods. I informed them about the progress I was making and during April of the second year I arranged times for their second interviews.

By this point two of the original thirty-two members of the group had left the school and three new pupils had joined. They asked to join the study and I, therefore, completed the first interviews with them before beginning the second interviews.

The period of time between the end of the second interviews and the beginning of the problem-solving sessions was seven weeks. I would have preferred to have had more opportunity to work on the data from the second interviews but there were organisational problems which made that impossible.

Videorecording of a group needs more space than an interview with one person. The equipment needs more time for setting up and dismantling and moving from location to location would not be easy or desirable. During normal term-
time in a busy school it would be almost impossible to find a reasonably large room which was free for more than one period. But in July when, because of external examinations, the fifth and seventh forms are no longer in the school the situation changes. The room I used was not free all day but the staff who would normally be using it were kind enough to take their classes elsewhere for the periods that I needed it.

When I originally discussed the project with the study group I had not contemplated the problem-solving sessions. In June I visited the group again and explained what I wanted to do. One more person had left the school by now and one person decided against joining in the problem-solving session. A third was not available at the time and a fourth took part in the study but was not included in the overall study for reasons which will be discussed in chapter six. So, at this stage of the study there were twenty nine participants.

I saw the group as a whole on only three occasions between the problem-solving sessions and the third interviews. By now they had moved from Lower School, which is a base for the first and second year pupils, into Main School and they no longer had tutor group periods during which I could visit them. Furthermore they now had a new group tutor who also happened to be new to the school. She was helpful and interested but lacked the knowledge about the study which the first group tutor had shared. However, I did, in addition, meet many of the pupils individually on a casual basis when I visited the school and a number of those pupils kept themselves informed about my progress.

By the time I arranged for the final interviews one more pupil had left taking the number participating down to twenty eight. The boy who had originally declined to join the study and then changed his mind now decided he did not want to take part in the final interviews. I eventually persuaded him to
do so by explaining the problems that would be created for me if he refused. This means that one small part of the study was obtained under some degree of pressure.

3.7.5 Locations of interviews and problem-solving sessions

In connection with the types of interviewing techniques I used, the location, a description of the room used and even the weather can be of importance. They are matters which help to decide how much at ease the interviewees feel and therefore provide some indication of how natural the interviews will be. They are also part of the thick description which allows for comparison with other studies.

For the first interviews my main concern about rooms came from the fact that the pupils were relatively new to the school. For them to be at their ease I felt that it was important for them to be in Lower School where they had a secure base and where most of their lessons took place. I wanted to use only one room if possible and also to ensure that the room had no connection with authority. This meant that I could not use the offices of members of staff when they were free.

I eventually settled on a small room which was not being used for anything in particular at the time. It had been an office but it faced north, was ill-lit and very cold. It contained two rather battered tables, three chairs and an assortment of props for the school drama department. I brought in a heater of my own, tidied up the room, swept it and hoped for the best.

The pupils did not seem to mind the state of the office and the heater took away the chill. Schools are not expected to have much in the way of home comforts anyway. There was, however, one other problem. The office was near an outside
door which was used by groups on their way to and from the
sports field and the beginning and end of interview sessions
tended to be accompanied by rather a lot of noise. It
disturbed me a little but the pupils seemed unconcerned.

By the time we came to the second interviews the office
was being used as a storeroom so I had to look for other
accommodation. Attached to the Lower School building but
separate from it is an area known as the Youth Wing. It is
used mainly in the evenings by older pupils from the school
but is open during the day and is used for such things as eye
tests and a venue for some mid-week sports for the sixth and
seventh formers.

I negotiated the use of a small side room in the Youth
Wing. It was always free when I needed it. It was carpeted,
had curtains, armchairs and tables and was warm. It had two
disadvantages. It was separated from the main hall of the
Youth Wing by a glass partition. This meant that although we
could get privacy by drawing the curtains it was, on
occasion, noisy. The second disadvantage was that the
exterior wall was damp and the room smelt somewhat fusty.
Although it was May the weather was cold and it was not
possible to leave the windows open for long periods.

The use of a different room did not seem to have an
adverse affect on any of the pupils. In fact, quite the
reverse. They were by now sufficiently seasoned members of
the school to feel at home in most places. The office of some
senior member of staff might have induced nervousness but a
comfortable room provided a pleasant change from the normal
school surroundings and some pupils commented on this fact. I
seemed to be the only one offended by the fusty smell or the
noise but perhaps the pupils were just too polite to comment.

The problem-solving sessions took place in the language
laboratory. This was conveniently close to the resources room
where the video equipment was stored. It was also very
pleasant because the room was carpeted, there were curtains at the windows and attractive posters on the walls. Because of its purpose it was a room with which all the pupils were familiar; all classes are taught there occasionally. The only problem we encountered was that the weather was very hot at the time thus making it necessary to have the windows open. This exposed us to noise from the playing fields but it was not excessive.

By the time of the third interviews the fifth and seventh forms were once more absent from lessons because of external exams. This time I chose a small classroom normally only used by A-Level pupils. I did not return to the Youth Wing because by now the study group were having almost all their lessons in Main School and it was easier for them to come to me there. There were no small offices free on a continuous basis and, for acoustical reasons as well as comfort, a small classroom seemed to be the best compromise. There was nothing in particular, except its size, to distinguish this classroom from any others in the school. It was light and airy and there were two rows of tables placed together, boardroom fashion, in the middle of the room. The only other furnishings were chairs and two cupboards. It was less comfortable than the two previous venues but quite in keeping with what the pupils were used to in their school lives.

3.8 Summary

In summary, having chosen the school and gained permission for entry I selected for study a tutor group who were new to the school. I spent some time acquainting them with my research and the methods which I intended to use and then I interviewed each one of them about their attitudes to, and beliefs about, some of their school subjects.
The following year I returned, and interviewed the pupils once more. On this occasion I talked to them about mathematics. A few weeks later, in order to obtain behavioural evidence to corroborate or refute the evidence from the first and second interviews, I videorecorded the same pupils, in groups of three, engaging in problem-solving sessions.

I used the data from the first and second interviews as the basis for developing a number of questions which I asked the same pupils, using an open ended format, approximately a year later.

All the data was analysed using methods developed for the grounded theory approach. The data was used in two ways. One use was the generation of statistical information about the whole group. The second was as a basis for case studies of individual pupils.
Chapter 4

FIRST INTERVIEWS: CONSTRUCTS ABOUT SCHOOL SUBJECTS

Introduction

As I briefly mentioned in chapter three (3.2) I felt that it was important to learn something about the pupils’ attitudes to and beliefs about all school subjects and, indeed, about school in general so that I would have a context in which to consider their attitudes to mathematics alone. Thus this became the purpose of the first interviews.

I did not have much difficulty in coming to a decision on the method I would use for interviewing. I had already determined that when I came to the interviews about mathematics alone I would use the Repertory Grid technique as a method of data collection and it seemed an eminently suitable tool to use for gathering data in these first interviews as well.

Given that the possible success of this study depended on my accessing the pupils’ own beliefs and attitudes, asking questions which reflected my own or other people’s views about what those beliefs and attitudes might be could be counterproductive. I needed an approach which would avoid this.

Repertory Grid technique is an excellent tool for this purpose. Elements are chosen which are both representative of the topic under discussion and meaningful to the interviewee and, using these elements, constructs concerning the topics are elicited by the interviewer from the interviewee. The interviewer acts more as a facilitator than a questioner and what emerges, if the technique is correctly used, is unique to that individual.
There are a number of variations on the approach. Ideally the interviewees will choose both the elements and the constructs. Sometimes, and probably not very usefully, the interviewer provides both the elements and the constructs. In other cases the interviewer supplies only the elements.

In this instance I wanted to talk to the pupils about their school life through the subjects they were studying and so I decided to use these for the elements, but for the pupils then to form the constructs. However, as I explain below, I did manage to allow for some individual choice.

4.1 Preparation for the interviews

4.1.1 Selection of elements

It is quite usual for nine elements to be chosen because they can be placed in a three by three grid, numbered, and then selected for discussion in eight different triads corresponding to the lines, columns and diagonals of the grid.

For these first interviews I prepared fourteen possible element cards in advance (see Appendix B1). The cards were light blue and their size was seven and a half by three and three quarter centimetres. I used Letraset capitals to label the cards with the names of all the subjects that were being studied by the group at the time. Each card was covered in clear plastic. This was partly to ensure that the cards were in the same condition for all pupils and partly to make it possible for numbers to be written on them and later erased.

During the first year the school divided the pupils into groups which, during each term, studied one subject from cookery, needlework, woodwork and metalwork. The following terms they changed to another of these subjects. Since the
first interviews took place in the Spring term of the first year each pupil had studied one of the above subjects and was in the process of studying a second. They had not had contact with two other subjects. But, of course, the two unknown subjects varied from pupil to pupil whilst the other ten subjects were shared.

There were two pupils who were, at this point, attending remedial lessons and did not, for example, study French. And although they studied English and mathematics they did so in the remedial unit and not with the other members of the group. However the problems of interpretation which this could create do not arise partly because both pupils had, eventually, to be dropped from the study and partly because, as I will explain below, these factors were not important to the study. I explained in chapter three (3.7.4) that one pupil was not available at the time of the videorecorded problem-solving sessions. The other pupil was dropped from the study for reasons which I will explain in chapter six.

4.1.2 Arranging the interviews

As I explained in chapter three (3.7.4) I had, a few weeks previously, spent an hour with the whole study group explaining the purpose of my research, how I planned to carry it out and why I had chosen that approach. During the week prior to the start of the interviews I spent another hour with the group during which they all practised forming constructs using elements selected by me and by various members of the group.

At the end of this session I asked for volunteers who would make arrangements for the first few interviews. I surmised that there would be some pupils sufficiently self confident to come forward and arrange to be interviewed while
others would hold back until they had reassurance from those who had talked to me. I wanted to cater for this.

When those interviews were half completed I returned to the group and the rest of the pupils willingly arranged to see me. I encouraged them to choose their own times. As I mentioned in chapter three there was one boy who refused to take part but he had made that decision at an earlier stage and, in fact, changed his mind later and asked to join in.

During this week I also made arrangements for the use of a room in which to conduct the interviews. In chapter three (3.7.5) I mentioned my criteria for this and explained that these led to my using a small cold room which had the minimum in the way of comforts and was, at times, noisy when groups of children passed by on their way to the sports field. It seemed to me, when it came to the interviews, that although I found all of this something of an irritant the pupils did not even seem to notice. Of course, by comparison I spent considerably more time in there and anyway, the irritant was something I had deemed worthwhile to ensure that pupils would remain in their own milieu.

4.1.3 Pilot study

I did not undertake a specific pilot study for the first interviews. Since I had been working at the school only months before and had, anyway, made my own preparations for conducting the interviews I felt confident that there would be no unforeseen hitches. On the other hand I did conduct a type of pilot study when I spent some time learning how to collect constructs. I had a practice session with Maureen Pope who is skilled in the practice and I also attended a workshop at Brunel University. My pilot study can be said to have taken place when I later practised collecting constructs
from family and friends including young people of the age group with which I was planning to work.

4.2 The interviews

The first few minutes of each interview were spent in attempting to help the pupils to feel at ease and to prepare them for what was about to happen. Instead of having everything prepared in advance I incorporated the preparation into the interview. Since the interviews were to be tape recorded I asked each pupil to help me to set up the tape recorder and to test the tape before starting, as well as setting out the cards which I had prepared to represent the elements.

I also used this preparation time to remind the pupils of the process for eliciting constructs and to reassure them about confidentiality and the fact that they were not being tested in any way.

I hoped that starting the interviews in this way would underline the notion of a joint venture. In our earlier discussions I had stressed the importance of planning the study in such a way and said that I hoped that that was how they would regard it; a somewhat pious hope perhaps, given the context of a school and the fact that the interviewing was being conducted by an adult. Nevertheless I hoped that awareness that participation was voluntary, together with my whole approach, would gradually lead to a feeling of involvement on their part.

I soon realised that involving pupils in preparations for the interviews would also give more substance to the individual profiles which I was attempting to create. Some pupils rapidly took the initiative in helping me; some kept within the limits of any request I made and some were
somewhat reticent. The potential danger of my questioning being affected by such behaviour was mitigated by the fact that I was eliciting constructs rather than asking specific questions but I did attempt to stay aware of the problem on all the occasions on which I was in contact with the pupils.

Once the cards were laid out I asked the pupils to select those which represented the three subjects they most liked, the three they least liked and any other three. I explained that these would be the elements for this interview and the other five cards were put on one side. In this way some individual choice in the selection of elements was possible.

Permitting a degree of freedom in the selection of elements meant that the group could not be compared subject by subject. This was not my intention anyway. Fortunately, although I did not request it, each pupil chose mathematics as one of their elements. I do not know if this reflected the importance they attributed to mathematics or merely a tacit acknowledgement that mathematics was what it was all about. I did not ask because I did not want to draw attention to this fact during the first interviews.

The nine cards were then turned face down, mixed up and numbered in as random a fashion as possible so as not to influence the order in which the triads arose. The names of the elements were filled in in the spaces prepared for this on the construct forms (see Appendix B2) and the pupils were asked to place the first three elements on the table in front of them. We were now ready to begin.

Using the customary methods of the Repertory Grid technique I asked the pupil to think of a way in which two of the elements were alike and the third one was different. I urged them to think of what seemed important to them rather than considering what type of answer I might be wanting. Of course they had already had experience of doing this the previous week when we had the group practice session in the
classroom although on that occasion the topics under
discussion were quite different.

Once they had found one end of a construct I asked them
to state the way in which the third element was different
from the other two. The fact that a construct has, so to
speak, two ends does not necessarily mean that it is bi-
polar. I tried to ensure that the pupils were aware of this
because it is only too easy to slip into the assumption that
bi-polarity is what is required.

Both ends of the construct were then recorded at either
side of the construct form, the end for the two elements
always being recorded on the left hand side as is customary.
The reason for this will become clear.

This done the pupils were then asked to rate each of the
elements on the construct and the ratings were recorded under
the relevant element between the two ends of the construct.

To clarify this I will use an example. Let us assume the
simple bi-polar construct of 'I like these two subjects and I
don't like the third one.' Once the construct had been
recorded I would tell the pupil that if they liked a subject
very much then they should rate it as one since liking was at
the left hand side. If they really disliked it then the
rating should be five. Various degrees of like or dislike
should take interim ratings.

Having completed this I then asked the pupils if they
could think of any more ways in which two of these elements
were alike and one different. If they could I recorded them.
If they could not, we moved on to the next triad and so on
until all the triads had been exhausted.

Initial constructs are often vague or ambiguous. When
they were, I asked the pupil concerned to either explain why
he or she had produced that construct or to provide concrete
examples of what was meant. In this way, with perhaps more
such specific enquiries from me, the pupil would usually
arrive at a construct which was more definite and understandable.

This is the usual approach to construct formation and it held particular appeal to me because I was much more interested in the explanations than in the constructs. In fact the constructs were, in this instance, mainly a vehicle for accessing the pupil's ideas without my asking more than the question why or making a request for an example.

I asked these questions even when the constructs were quite clear but the pupils did not seem to mind. In fact many of them remarked at the end how enjoyable it had been to take part. No doubt this was because twelve year olds, particularly in the school situation, rarely have the experience of an adult spending approximately an hour and a quarter avidly listening to their views.

At the end of the interview I explained to the pupils just what I was going to do with their constructs and their tape recording; reminded them that I would be talking to them again in due course and thanked them.

4.3 Analysis

4.3.1 The conversations

I transcribed each interview verbatim using a word processor but I did not carry out any detailed analysis of the conversations. As I remarked earlier these interviews were for background information and, for this study at least, I had no interest in any general categories that might have been produced.

However, the information, as it stood, was buried in much irrelevant data and so, to facilitate understanding, I extracted the main points from each transcript and retained
them for further use.

Further use in this case refers to a little more than background material. I hoped to be able to discuss the points with each pupil at a later date as a way of checking to see if their views had changed in any way. I was able to do this at the end of the third interviews as I explain in chapter seven.

4.3.2 The constructs

Because the main purpose in eliciting the constructs was as a non-directive way of accessing the pupil's attitudes to and beliefs about school there was, at least for this study, no pressing need for me to analyse the constructs. However, since I had to hand a ready tool for analysis and I knew that a number of interesting individual points were bound to show up, I could not resist the temptation to see what I could learn from them.

To analyse the constructs I used a computer programme called Focus. This is a method of cluster analysis. The data - in the form of the number of the elements, the constructs, and the ratings - is fed into the programme which then computes and prints out a construct-matching score matrix and an element-matching score matrix. The programme also computes a construct tree and an element tree which contains data concerning the percentage relationships between the scores. It reorders the original grid to fit with the trees and prints the re-sorted grid together with the trees thus allowing one to see quite clearly the strength of the relationships between constructs and between elements.

Two points did arise from the grid analysis. The first was that I noticed a tendency in top set pupils to produce constructs which related more to external factors whilst
lower set pupils tended to produce constructs which related more to personal factors. Examples of the former are 'To do with/not to do with different countries' and 'To do with nature/to do with people'. Examples of the latter are 'I like/dislike them' and 'I get/don't get good marks in them'.

Nine out of twelve pupils in the two top sets produced more constructs relating what I classified as external rather than personal factors whilst only two out of the twelve pupils in the bottom sets did so. On the other hand, seven of the pupils in the bottom sets produced more constructs relating to personal factors whilst only two members of the top sets did. The other four, one from the top sets and three from the bottom sets, produced an equal number of each type of construct.

Twelve pupils in each of the groupings does not accord with later chapters where I refer to fourteen in each grouping. This is the result of changes in group structure to which I referred in chapter three (3.7.4). I do not refer, here, to anyone who took part in the first interviews but later left the study. Nor do I refer to the four other pupils who entered the study at a later date. The latter all gave interviews identical to these but, since they took place a year later, I have excluded the data because of the age difference.

The second point concerns the relationship between maths and English although, since a number of pupils did not use English as an element, this finding is very tenuous. I noticed that the grids of top set pupils tended to produce a stronger relationship between the two subjects than did the grids of bottom set pupils.
4.4 Conclusions

As I said earlier, the conversational analysis was used essentially as background information and I made no comparison of data for different students. What I can say is that the method proved to be extremely useful as a non-directive method of accessing pupils' ideas.

The fact that there were differences in the type of constructs made by top set pupils and bottom set ones is really quite interesting. I had made a point of stressing that what I hoped they would give me were constructs which were personal to themselves. I suppose it could be argued that the pupils who gave me constructs which related more to external factors were discussing what was personal to them. I did note, during the interviews, that some pupils seemed to be giving what to me were external factors, but at that time I had deliberately not found out about pupils' mathematics settings and it was, therefore, only later that I noted the connection with top and bottom setting.

It can only be speculation, but it seems reasonable to wonder if these pupils had already, and perhaps as a result of their family background as well as schooling, adopted the cultural notion that one ought to try to be objective. I feel sure that such an attitude could be helpful towards success in school mathematics.
Chapter 5

SECOND INTERVIEWS: MATHEMATICAL CONSTRUCTS

Introduction

In this chapter I will describe how I developed a method for using mathematical topics as elements for three different constructs. As I mentioned in chapter three (3.3), I did this in terms of three pilot studies because the first two were negative and only the third one yielded a positive result and led to the gathering of data in the actual study of mathematical constructs.

5.1 First pilot study

In chapter three (3.3) I briefly indicated that I began to entertain doubts about the suitability, for use in the second interviews, of the Repertory Grid technique used in the first interviews and that because of my doubts I decided to run a pilot study. The results of this study demonstrated that my doubts were well founded.

The doubts arose from discussions with three of my own children, now grown up, all of whom had O-Level mathematics and two of whom had A-Level mathematics. Each of them had been among the group of people who acted as respondents in order to help me to develop my skills in eliciting constructs and they had now agreed to help me again by acting as "guinea pigs" for the second interviews.

Using mathematical topics as elements I used the same approach to eliciting constructs as that described in chapter four. All three of my children found the task very difficult.
They said that it seemed forced and unnatural. They agreed that the reason for this could be that there was a gap of from three to six years since they left school but the experience was sufficient for me to decide to run a pilot test with a group of children from the same school as my study group.

The pilot study began near to the end of the Autumn term of the study group's second year in the school. There had been a break of some eight months since the previous interviews took place. During that time I had analysed the data collected at those interviews but there was also a period of a few weeks when I chose not to interview pupils because of the teachers' industrial action. I had no reason to believe that this would in any way affect my work but I deemed it wise to be cautious. Had the industrial action in any way disturbed the pupils then this would have affected them in unknown and unknowable ways.

I invited six pupils to assist me. They were all members of the same year group as the pupils in my main study group and, in order to have respondents of the same range of ability as that group, the pilot study group were chosen to represent each of the maths sets for the year. That was the limit of my attempts to choose similar respondents. The deputy headmistress knew the pupils and with her help each one was selected on the basis of their ability to communicate. If the method of eliciting constructs was unsuccessful I wanted to be as confident as possible that this had occurred because the method was unsuitable for the purpose rather than because I was having difficulties in communicating with the pupils.

Before doing the pilot study I interviewed each of the pupils and very carefully explained the purpose of my study and the reason why I was asking for their help. I also worked through the method for eliciting constructs using the same
approach as I had used with the main study group in the first interviews (chapter four (4.2)). All six were willing to assist me and I arranged times to interview them.

The interviews took place over a period of three days using classrooms which happened to be empty at the time. As a result, four different rooms were used but they were all in the Lower School where the pupils were based and were rooms with which they were familiar.

If the pilot study was successful I intended to provide, as elements for the second elicitation of constructs, all the mathematical topics the main and pilot study pupils had covered in their time in the school. The pupils would then choose nine of these elements as they had in the first interviews. However, for the purpose of the pilot study, I myself chose the nine mathematical topics to be used as elements. I did this in order to ensure that each pupil had the same combination. At this point I was more concerned about the possibility of eliciting constructs than with their possible range or quality.

The elements were addition, subtraction, multiplication, division, fractions, sets, angles, coordinates and symmetry. They were chosen because my own experience of teaching mathematics in the school made me confident that each pupil would be familiar with the topics and would have recently worked with them.

The names of the topics were hand printed on the same type of small, pale blue cards as had been used in the first interviews. They measured 7.5cms by 4cms. The constructs were recorded using the same method as in the first interviews and, as before, the interviews were tape recorded with the interviewee wearing a lapel microphone.

The only difference in methodology between the first interviews and these pilot study interviews was that I spent some time at the beginning of each session discussing each of
the topics to ensure that the pupils and I were sharing the same concepts. I did so because my own teaching experience made me aware that while pupils may know how to work with a particular topic they do not necessarily remember the label for that topic until they are reminded of it.

The outcomes of the pilot study interviews were uniformly disappointing, particularly when compared to the first interviews. Then, most pupils had clearly enjoyed what they were doing and had produced meaningful constructs in a conversational manner. Now, very few constructs were produced and the pupils were clearly labouring to make sense of the exercise. When I asked for their views they said they did not like doing it. The consensus was that it was a silly and meaningless exercise. I decided to look for another approach.

5.2 Second pilot study

After much thought and discussion with colleagues I decided to do a second pilot study using stimulus material as a basis for asking a number of open ended questions.

The topics for the stimulus material were the same as those used for the first pilot study (5.1 above) with the addition of decimals, relations and area. I also used two categories for fractions. One was addition and subtraction of fractions and the other was multiplication and division of fractions. My reason for increasing the number of topics was that I was no longer constrained by the selection of nine elements from which to elicit constructs.

In the first pilot study I had attempted to elicit constructs about learning mathematics by asking in what way two topics were the same and the third one different. Now I hoped to elicit constructs by presenting to the pupils stimulus material for each topic and asking them if they
enjoyed doing the topic and why they did or did not enjoy doing it. The answers to these questions were to be spring boards to further questions and in this way I hoped to uncover their attitudes and beliefs about doing school mathematics.

To this end I took great care in preparing stimulus material which I thought would be visually pleasing. For the arithmetic topics I photocopied pages from basic mathematics workbooks and the others were photocopied from the S.M.P. books A to D. The pages were photocopied on white paper and were then mounted on sheets of bright green card to provide a frame. The cards, which measured 15cms by 20cms, were then covered with a transparent material to provide a clean professional looking finish. Copies of the stimulus cards are shown in Appendix C1.

My methods for recruiting and interviewing pupils for the second pilot study were the same as those used in the first pilot study (5.1 above) except for the fact that this time I did not instruct them in the methods of eliciting constructs. Instead I simply described the approach I would be using and why I was doing it that way.

Once again all six pupils agreed to take part. Times were arranged and, as before, the interviews took place over a period of three days in a number of empty classrooms with which they were familiar. As before, the interviews were tape recorded. The interviews took place in March of the second year. I stated clearly at the start of the interviews that I did not want them to answer the questions but to talk about the topics.

The results were again disappointing. This was partly a result of my own inadequacies. I found it very difficult to be non-directive under these circumstances and the pupils slipped very easily into a pupil teacher type of relationship.
I discussed this with each pupil at the end of each session and learned that one reason for this was that the pupils found themselves searching for things to say and were only too happy to leave the initiative to me.

I also gained the impression, from the pupils' comments, that the stimulus material played a part in this. My attempts at making this material look attractive and professional had only served to make it look like lesson material and indeed the interviews were frequently in danger of turning into private tutorials with the pupils wanting to discuss the methodology for individual topics rather than their own attitudes and feelings about mathematics in general. At that point they would begin to forget the purpose of the interview and think of it as a testing situation. This was inhibiting and the flow of conversation tended to dry up even further.

I decided that this approach was also unsuitable. However, I hasten to add that in the right hands it may be a suitable tool. It is quite possible that a more skilled interviewer could have ensured that the interviews developed in the desired direction. I clearly did not have such skills nor the time to develop them so I decided to try yet another approach.

5.3 Third pilot study

It was my good fortune that a few weeks later Phillida Salmon, a lecturer at the London Institute of Education, gave a talk on 'Alternatives to Repertory Grids' to the Barbicon Grid Group of which I am a member. As a result of her talk I learned of another method she quite frequently uses for non-directive questioning. Using the construct like/dislike she asks interviewees to rate elements on a scale of nought to seven and then uses the ratings as a basis
for discussion. I decided that this might well be the method I was looking for.

Because the method was tried and tested in other circumstances I decided on a smaller pilot scheme using pupils who were already familiar with my work. I asked for the help of three pupils who had been particularly useful in identifying faults in the previous pilot studies. One had taken part in the first pilot study and the other two in the second one. Once I had explained the new approach all three readily agreed to take part and the interviews, which were recorded, took place the next day in empty classrooms. They took place at the beginning of May in the second year.

Some time had now passed since the first pilot study and the three pupils involved, as well as the main study group, had covered more topics in their mathematics lessons. Consequently I increased the number of topics to be covered to eighteen by adding, to the earlier topics referred to in 5.1 and 5.2 above, number bases, decimal places and significant figures, route matrices, positive and negative numbers and statistics. My purpose in extending the number of topics was simply to widen the range of possibilities for sources of comment.

Experience in the first pilot study had indicated that I was right to be dubious about the ability of pupils to remember the labels for various mathematical topics even when they can work with them (5.1. above). On the other hand, experience in the second pilot study showed very clearly that professional looking stimulus material had undesired effects on pupils (5.2. above). I compromised. I did not write the name of the topic but instead, in my own handwriting, I put down examples of the topics on cards measuring 10cms. by 6cms. I also wrote in the answers to the examples in order to reduce the possibility that the pupils would feel that they were being tested. The cards are shown in Appendix C2.
The method used was as follows. I cut small blue cards into two and on each half wrote a number from nought to seven. These were laid out across the desk with nought at the left and seven at the right. The eighteen topic cards were well shuffled and given to the pupil who was asked to place them one by one under the relevant number according to how much they liked or disliked the topic. If they disliked them very much then they went under nought and if they liked them very much under seven. When the cards were in place I then asked each pupil to explain why they liked or disliked the topic. We began our discussion with the least liked topics and worked on to the most liked ones.

My interest was not with the extent to which pupils liked or disliked topics. I was using this form of questioning as a non-directive way of introducing pupils to a discussion of attitudes towards and feelings about mathematics. I therefore allowed the conversation to follow where the pupils wanted to take it, provided it did not stray totally from the point, but I made no effort to encourage the development of comments that related only to liking or disliking.

When all the topics were covered in this way I gathered in the cards and shuffled them. The whole process was then repeated twice. On the first occasion the pupils rated the topics for ease or difficulty and on the second occasion they rated the topics for their usefulness. Extreme difficulty was to have a nought rating and extreme ease a seven. Completely useless earned a nought rating and very useful a seven.

Introducing the further constructs of ease or difficulty and of usefulness was a departure from the method suggested by Phillida Salmon but, I believe, equally valid in the circumstances. I felt that easy/difficult as a construct was likely to lead to the raising of a variety of issues which might differ from those raised by the construct like/dislike. At the same time, usefulness led straight to one which I knew
to be very pertinent to many children. Only too often one hears, as a mathematics teacher, the question, "Why are we learning this topic? What will we ever use it for in real life?" I felt it might be valuable to hear the pupils' views on this and I further believed that it might lead on to other issues. I was not expecting objective knowledge about uses. I was expecting the pupils' own ideas or even rationalisations when faced with the need to think about it.

At last I had found a method which seemed to serve my purpose. The three pupils I talked to were now responding in a way which, intuitively, was similar to the responses I had obtained during the first interviews. The method seemed natural and reasonably interesting to both myself and the pupils. Indeed they said afterwards that they found this approach quite acceptable.

I found the task of eliciting the ratings somewhat tedious and was afraid the pupils would feel the same. My fears seem to have been unfounded. The pupils were concentrating on something they had not given much thought to previously and they found it an interesting experience. I suspect that my own feeling of tedium had its source in the belief that the ratings were a necessary stage in getting to the real point of the interviews but had no intrinsic use. Later I was to see a statistical use for the numbers but at this stage I thought of them only as a necessary evil.

From an interviewer's point of view, I became aware of one advantage that this method has over construct elicitation on those occasions when the method is being used as a means of non-directive questioning. The rating of elements for each construct takes place after the construct has been discussed and when, knowing that the ratings are not one's main concern, one is eager to move on to the next stage. Using the method under discussion here the rating takes place first and does not intrude on the main discussion.
Another happy accident extended the range of the interviews. At the end of the first session I asked the pupil two specific questions. The first question asked for a description of his ideal mathematics teacher. For the second question I put the rating cards 1, 2, and 3 in front of him and asked him to imagine that they represented three pupils. Pupil number one was at the top of top set and really succeeding at mathematics. Pupil number two was in the middle of the middle set and was neither a great success nor a complete failure. Pupil number three was down at the bottom set and failing miserably. I asked him to give his ideas about why the pupils might each be in their stated position.

Asking these two questions departed from the non-directive aim of the interviews but the situation arose spontaneously at the end of the interview and was not, at that stage, seen as part of it. However, since the pupil seemed genuinely interested in discussing the matters raised I decided to repeat it with the other two pilot study interviewees. They also showed interest and since it seemed to be useful information which might not arise from all non-directed interviews I decided to incorporate these questions into the main study interviews asking them at the end of the main questioning session when all other avenues had closed.

The pilot study pointed up one way in which responses to the last question about the three pupils might vary. Two of the respondents talked about hypothetical pupils but the third one selected known people to discuss. I decided to accept either approach in the main study.
5.4 Collection of data for the main study

5.4.1 Events leading up to the second interviews

Having found a method which seemed successful and in need of no further development I once again visited the main study tutor group. I explained the change of approach and the reasons for it and arranged to interview members of the group on occasions that were convenient to them.

As with the previous interviews I noted that for some pupils, enthusiasm lay more obviously with the prospect of escaping disliked lessons rather than in talking to me. Others were keen to talk but preferred not to miss well liked lessons. The result was the same but the distinction was noticeable. I did not find any reluctance to be interviewed. In other words, everyone came forward to negotiate a time. Nobody said anything which amounted, in effect, to, "Do I have to?"

The interviews took place in early and mid May of the second year. Their location is described in chapter three (3.7.5).

5.4.2 The interviews

The first few minutes were spent talking to pupils to remind them of the purpose of the interviews, to put them at their ease and to ensure them of confidentiality. On this occasion, because we were dealing with mathematical material, I was particularly careful to stress the non-testing nature of the interview.

Before beginning I went through the cards to make sure that each pupil was familiar with the topics. After several interviews I encountered a member of set five and discovered
that sets five and six had not been taught some of the topics. On that and subsequent occasions where individuals were from these sets we removed the unfamiliar topics and I later rated them as noughts but with an asterisk to demonstrate the difference from other noughts.

In the pilot study the pupils themselves placed the cards under the relevant number for scoring. The physical lay out of the interview room for the main study made this impossible. The location of the only electric plug socket in the room meant that I had to sit in one particular chair to be near the tape recorder. This was also the only chair from which one could easily reach out to put the cards on the table. To save the pupils from constantly jumping up and down they handed the cards to me and told me where to place them. This did have one advantage. The fact that the location of the cards was recorded on tape made it unnecessary for me to write down that information. The process was slightly speeded up and that allowed more time for talking. Each interview lasted approximately one and a quarter hours.

Apart from the differences described above the interviews proceeded in the same way as described in 5.3 above for the third pilot study.

5.5 Analysis of verbal material from the second interviews

The conversation from each interview was transcribed verbatim using a word processor. Any data referring to the rating of mathematics topics was then set on one side as were my questions. This left the comments made by pupils which were then analysed to find categories of statements.

This type of open ended questioning inevitably produces a wide range of responses. Here the responses fell into three clearly separated groups: those by a large majority; those by
a significant minority and those by a few. Those which were raised by the majority will be discussed here. Those which were raised by a large minority were incorporated as questions to be put to the whole group in the third interview. A few of those statements raised by only one, or one or two individuals were also incorporated as questions put to the whole group in the third interview which will be discussed in chapter seven. The criterion for their inclusion was whether or not I considered them to be of interest to the study.

This is an extremely subjective criterion but one which I believe I can justify. My reason for using a non-directive approach in the first and second interviews of this study was concerned more with accessing relevant information than it was with avoiding that which is irrelevant. What was important was that I did not, by asking my own preconceived questions, block access to that which I really wanted to know. However, in an interview lasting just over one hour it is highly likely that not all the factors which influence people will be mentioned by even a substantial minority. In principle any one of the statements made by one, or one or two, pupils might have been thought of by all the other pupils if there had been time. That would suggest that it would be useful to incorporate every one of them as questions in the third interview. In practice there were too many statements for it to be possible for me to do this and for this reason I had to be selective. Consequently I chose the criterion of interest in order to select those of the tiny minority responses which I would include and assume might have been made by many.

If I chose irrelevant subject matter the responses should indicate this. Unfortunately, it is also the case that if I left out statements which would have turned into relevant questions then I will never know. However, at least a
definite attempt will have been made.

Nine categories of statements were identified which were made by all or almost all respondents. One of these was inevitably common to the whole group since it was a response to my final, somewhat leading, question about the reasons for the success or failure of hypothetical pupils. The response was concerned with whether mathematical success comes from a pupil's own efforts or from inborn characteristics. Two others arose from my question about an ideal maths teacher. Although this was not inherent in the way the question was worded the two responses were common to almost the whole group. The two categories concerned were whether or not the teacher ought to be strict and whether or not the teacher's personality matters.

For the other six categories any that were not addressed by the whole group were raised as individual questions at the end of the third interviews for those who had not referred to them in the second interviews. To that extent they should, perhaps, be counted as part of the third interview data for those pupils. However, very few pupils were involved and I have decided that it is more meaningful to use the responses here to allow for comparisons to be made across the group.

Each category effectively divides into polar opposites. Consequently it is useful to divide the nine categories into eighteen statements. I did this and then divided the statements into two groups. I hypothesised that one group of statements would refer to beliefs the holding of which would be helpful in learning mathematics and I hypothesised that the reverse would apply to the other group.

The nine categories hypothesised as advantageous generalise as follows:-

1) I can work when there is noise and other people are messing about.
2) When I find the mathematics difficult to understand I keep trying.
3) There is no need for the mathematics teacher to be strict.
4) My parents help me with my homework.
5) The personality of the mathematics teacher does not matter.
6) Understanding what you are doing in mathematics is more important than being able to do the work.
7) Learning in mathematics depends on how hard you are prepared to work.
8) I would rather do problems than sums.
9) Diagrams can help when you are doing mathematics.

The nine categories hypothesised as being disadvantageous generalise as follows:

10) I cannot work when there is noise or other people are messing about.
11) When I find mathematics difficult to understand I give up.
12) Mathematics teachers should always be strict.
13) My parents do not help me with my homework.
14) The personality of the mathematics teacher does matter.
15) Being able to do the work is more important than understanding in mathematics.
16) Learning in mathematics depends on inherited characteristics.
17) I would rather do sums than problems.
18) Diagrams make no difference when you are doing maths.

Two sets of explanations are necessary here. The first
concerns the nature of some of the statements. Apart from statements 6, 8 and 9 and their opposites 15, 17 and 18 all the statements could be made about any subjects and not just specifically mathematics. However, the pupils consistently differentiated between mathematics and other subjects with the occasional exception of foreign languages. In negative terms, there was the claim that whatever tended to be the case in other subjects would be very much the case in mathematics. For example if someone finds it slightly difficult to work at any time when there is noise there is the likelihood that they will find it very difficult in mathematics.

The second set of explanations has to do with my reasons for placing statements under one hypothesis or another. My arguments were as follows:

a) Statements 1, 3, 5 and 7 were labelled as potentially advantageous because I hypothesised that they reflect beliefs and attitudes which suggest an inner locus of control, a belief in one's own ability to act on the world and influence it regardless of what others might do or say.

I must confess that it was neither inspiration nor contemplation which led me to treat statement 1 as advantageous. It was observation. I began to notice a pattern as I talked with pupils. At first I was sceptical because the pupils who first told me that they could not work when there was noise were pupils whom I knew to be 'naughties'. They claimed that when there was noise they gave up and joined in and it sounded very much like special pleading. I decided that they were just trying to lead me on. But gradually I had to take notice as others from lower sets made similar remarks. Gradually I began to see the possible sense to it — particularly when I thought back to my childhood and realised that I had been one of those 'naughties'. I would remind the reader of my earlier remarks about everything being much more
so in mathematics than in other subjects.

b) Statement 2 is an attitude which must be useful under any circumstances and statement 4 is a fact which should also be generally helpful. 4 is not an attitude or belief and so, technically, does not belong here. I include it because it is a statement which arose regularly in either this form or as its polar opposite.

c) Statements 6, 8 and 9 were labelled as potentially advantageous because of my own beliefs. I have always believed understanding to be crucial for success in mathematics and since sums are problems stripped of their complexities a preference for problems suggests a willingness to face the degree of complexity which actually exists in mathematics. Finally my own experience as a mathematics teacher suggests that the use of diagrams tends to lead to a greater degree of success.

A discussion of my findings on these categories will take place at the end of this chapter (5.7). When I came to do my third interviews further categories emerged and these will be discussed in chapter seven.

5.6 Analysis of numerical data

As I remarked in 5.3 above my initial interest was not with the extent to which pupils find topics easy or difficult. I, therefore, at the time of the interviews, did not envisage any intrinsic use to the ratings but later I realised that they could serve a useful purpose statistically and at a more general level. I analysed the data at an individual level and for the group. For both levels I first divided the topics into two groups one of which I termed arithmetic and the other mathematical. Of the topics shown in Appendix C2, statistics, relations, sets, coordinates, angles, route
matrices and symmetry were grouped as mathematical and the rest were grouped as arithmetic.

5.6.1 Analysis at an individual level

In what follows, and at any future points, the pupils are numbered from one to twenty nine. The assignment was random. The information gained at an individual level was of two kinds. In the first case, the results of which can be seen in Appendix D Table 1, I separately summed the scores for the arithmetic group and for the mathematical group for each of the three constructs, easy/difficult, like/dislike and useful/not useful and then found the means. This gave me six sets of means for each pupil. For added convenience the means are listed in accordance with the mathematical sets in which the pupils were being taught at the time but the order within the sets is random.

The second way in which I used numerical data at an individual level was to discover, for each pupil, the degree of correlation between the three constructs of easy/difficult, like/dislike and useful/not useful. This information can be seen in Appendix D Tables 2A and 2B. Once again the information is listed in accordance with the pupils' setting as was described in the previous paragraph.

5.6.2 Analysis at the level of mathematics sets

a) This analysis was done, partly, at the individual level when, as explained in the final paragraphs of 5.6.1, I organised the information according to sets. As I discussed in chapter four, setting is one indicator that can be used, at a general level, to judge overall success in mathematics.
in school. In this group of pupils, at the time that this data was collected, there were nine pupils in set one, five in set two, five in set three, five in set four, and four in set five. There was one other pupil who was still in the study at this time but she had left the school by the time of the third interviews. I have omitted her data from this part of the study because I was unable to follow through on the questions. It is for this reason that there is no pupil number 24.

Sets one and two contain those pupils who are likely to be taking the higher levels of the G.C.S.E. mathematics examination. The other groups take the lower levels or no examination at all. It was this, together with the fact that exactly one half of the group are in the two upper sets, which led me to divide the group not only into sets but into two halves for comparison. The tables in Appendix D which give individual information thus divide into two halves. This includes the tables containing qualitative data as well as those which contain quantitative data.

To provide a clearer picture of any differences between the group who are more successful and the group who are less successful at school mathematics I summed the individual means from table D1. I did this first for the whole group and then for the two upper sets grouped together and the three lower sets grouped together. Finally, I found the means of these grouped means. Appendix D Table 3 shows these means totals and means of means of the three constructs for both arithmetic and maths.

b) The scores made by pupils for each construct were subjective even where the rating was for ease or difficulty. So, as a fairly gross measure of how realistic their ratings were, I grouped the pupils in two further ways. First I found the mid-point of the range of the total scores made by pupils for each construct in arithmetic and maths and grouped the
pupils above and below that point. For example, the range for easy/difficult in arithmetic was from 22 to 72 so I placed any one who scored 48 or above into the upper half and the rest below. I also grouped together the fourteen with the highest scores and the fourteen with the lowest scores irrespective of sets. This was also done for each construct in arithmetic and maths. The results are shown in Appendix D Table 4.

3) Finally, for each topic, I correlated each construct with the other two so as to have, at group level, the same information which I had already obtained at the individual level.

5.7 Conclusions

5.7.1 Conclusions from categories

As I explained in 5.5. above, a number of categories that were raised by a minority of pupils were turned into questions for the third interview. Here I will discuss only the nine more general categories which I identified.

To facilitate analysis I drew up a table showing the categories which I hypothesised would facilitate success in mathematics on the left hand side and those which I hypothesised would do the opposite, on the right hand side. I then ticked each pupil’s place on that table.

As I explained in 5.6.2, the information was grouped in accordance with the pupils’ sets with the higher sets first. In this way the table was divided into four quadrants. The information is shown in Appendix D Table 5.

If my hypothesis was correct then it should have been clear from the table. The top left hand quadrant should have many more ticks than the top right hand quadrant thus
demonstrating that the upper sets had tended to make statements in line with my hypothesis. The situation would be reversed in the two bottom quadrants.

Appendix D Table 5 does show this to a certain extent, at least for the upper sets. However it was clear that there were some anomalies. Appendix D Table 6 shows this. Here the statements are listed with an indication as to how many people from each grouping made them. To fit my hypothesis the first nine statements should have been made by more people in the upper two sets than in the lower three sets. This was not the case. Consequently I reorganised the categories using the same method as in Table D5 but reversing two statements so as to place on the left hand side all those statements made by more upper set pupils than lower set ones. The statements were 'Mathematics teachers should always be strict' and 'Being able to do the work is more important than understanding in mathematics'. This reorganisation can be seen in Appendix D Table 7. However, it must be noted that this table is not in agreement with my hypothesis. In fact, it comes out of the data i.e. it simply demonstrates that some statements were made by more upper set pupils than lower set pupils and it indicates what those statements were.

A much clearer picture now emerged. For the majority of categories there were only slight differences between the two groupings but there were three categories which clearly differentiated them.

The first category, 'I can work when there is noise and other people are messing about', was stated by nine of the fifteen pupils from the two top sets. Its polar opposite was stated by ten of the fifteen pupils in the lower sets. I have already discussed, in 5.5. above, the fact that my attention was drawn to this problem during the interviews although at that time I had been less aware of those pupils who do not find noise a problem. Clearly it can only be one among many
other matters which play a part in mathematical success or failure because a number of successful pupils find noise a problem while some of those who are less successful do not. Nevertheless it is a matter which calls for consideration.

It is quite possible that this is a problem which only appears in secondary schools when a more formal approach to learning takes place. When pupils are occupied and interested, 'messing about' is rare. And, although the situation is beginning to change, mathematics has been traditionally taught in such a way that pupils simply do the work rather than become involved in an activity. If this lack of involvement leads to noise and messing about then those who find this difficult to ignore will be greatly handicapped. Furthermore, if the same situation existed during mathematics lessons in the junior school then the likelihood is that such pupils will already have fallen behind their more resilient peers.

The second category which differentiated the pupils, 'When I find mathematics difficult to understand I keep trying', was made by thirteen of the fifteen more successful pupils, and its polar opposite, 'When I find mathematics difficult to understand I give up', was made by ten of the fifteen less successful pupils. While this result was more predictable, at least these were statements made by the pupils themselves and not by other people about them. As might be expected, the reasons pupils gave for either keeping on trying or giving up were not uniform. At the level of the group this is not relevant. Its relevance shows up only at the individual level when a constellation of factors is being considered.

The final categories did surprise me. Ten of the more successful group said that 'Being able to do the work is more important than understanding in mathematics', and nine of the less successful group said the opposite. I had, of course,
hypothesised the other way. I have always believed in the importance of understanding and always tried to help pupils achieve it.

Of course the fact that the more successful pupils stated that belief does not mean that they necessarily lacked understanding. It merely suggests a willingness to keep trying even when understanding is missing. On the other hand, the impression I gained from some of those who feel that understanding is important is that without it they cannot make progress. And, of course, mathematics is one subject which still tends to be taught algorithmically to a great extent. This is particularly the case in junior schools where the foundations are laid for success in the subject. There is, therefore, sense in this result as well. When mathematics is not taught for understanding it is clearly a disadvantage to feel the need for that understanding.

There are other possible reasons for these responses. For instance, it may be the case that pupils were giving different interpretations to their statements. This could have happened in at least two different ways. One possibility is that for some, understanding is simply a bonus, the main aim of schooling being to get good marks and stay at the top. Those who feel that way but are not handicapped by lack of understanding might well see success as the more important factor. A further possibility is that by 'understanding' some pupils meant 'knowing why they were doing the work' rather than understanding the meaning of the mathematics involved.

Unfortunately I did not consider the variety of meanings when I first encountered the categories and therefore did not follow the problem through at the third interviews. Later, when the various possibilities were pointed out to me by colleagues, I checked back through the scripts and found a deal of ambiguity. Interpretations of these statements are, therefore, not possible. This is a matter which should be
further investigated at a later stage by myself or others.

Before leaving the qualitative data I must comment on the fact that the picture seems much clearer for the upper sets than for the lower ones. Although Appendix D Table 7 was set out in such a way as to place on the left hand side those statements made by more upper sets pupils than lower sets pupils that inevitably means that the right hand side does the opposite. And yet, whilst the upper sets have clearly made more statements from the left hand side grouping the statements from the lower sets are very mixed. Put in numerical terms, almost two thirds of the statements made by the upper sets are on the left hand side of the Table but for the lower sets there are only two more statements to the right of the table than there are to the left.

One possible explanation for this could be that some of the statements are more socially acceptable than others. This would not necessarily invalidate them here, partly because they were not answers to questions but topics raised by the pupils themselves and also because acknowledging that which is socially acceptable and yet not behaving in accordance with it could have implications for success or failure in mathematics. It was with such considerations in mind that I decided to video record group problem-solving sessions to provide behavioural as well as verbal data. The results of these will be discussed in chapter six.

Whatever the case I feel that pupils were being as open and honest as possible. I think most people would see keeping on trying when things are difficult as being socially acceptable. Certainly many of the eleven pupils who told me that they gave up believed this to be the case. They showed varying degrees of embarrassment when telling me that they gave up but they still admitted the fact. And in the third interview a number showed equal embarrassment but the same degree of honesty when they admitted to copying.
Another, and I think, more probable explanation is that these are secondary factors which interact with certain major factors to help or to hinder. Two of the major factors which I have in mind are shyness, which is something which several of them referred to explicitly, and sheer determination to succeed in all school subjects, which came clearly through from the way they responded in general.

A somewhat salutary lesson for me lies in the fact that three categories which barely discriminated the two groups arose from my questions at the end of the interviews about the teacher and about how pupils come to be able or less able in mathematics. The results suggest that these may not have been matters of any great interest to the pupils themselves. If this is the case it does, at least, demonstrate the value of encouraging the pupils to produce their own statements.

5.7.2. Conclusions from statistical analysis of individual data

It was clear that, in general, pupils in this group find maths easier than arithmetic and clear also that they like maths more than they like arithmetic. However they all see arithmetic as being more useful than maths.

The correlation between easy/difficult and like/dislike is apparent for both upper sets and lower sets. This is hardly surprising. To like what you are good at or to be good at what you like, and the opposite of these two statements, is quite commonplace. However the degree of correlation tends to be greater for pupils in the lower sets. This may merely mean that dislike and lack of ability interact more potently than do liking and ability. On the other hand it may mean that where there is ability, factors other than liking may be involved. My discussions with the pupils suggest that both
factors are at work here and the fact that most pupils, even the more able, rate easy higher than liking tends to confirm my second suggestion.

Correlations for the two other combinations are much less clear. They are virtually non-existent for maths and this can almost certainly be accounted for by the fact that whilst most pupils could see little usefulness for most maths topics there was a tendency to like more and find easier those maths topics which were thought to be least useful. It is interesting to note that the majority of correlations between easy/difficult and useful/not useful and like/dislike and useful/not useful, whilst not significant are in a negative direction.

The correlations for these two combinations in arithmetic topics appear, at first glance, to be more complicated. However it soon becomes clear that almost all the significant correlations can be accounted for by a group of ten people, five in the two upper sets and five in the three lower sets, whose results correlate across all three constructs. A possible explanation for this group's ratings is that they are pupils who feel a need for things to fit together. If they find a topic difficult they dislike it and feel that it cannot be useful and vice versa. Unfortunately this explanation makes it difficult to account for the fact that they have not shown the same attitude towards maths topics.

It is interesting to note that as with the correlations between easy/difficult and like/dislike the correlations for the two other combinations in arithmetic topics are more significant for those pupils in the group of ten who are from lower sets.

The individual information displayed in Appendix D Table 1 was merged into group data in Appendix D Table 3. This further analysis did little more than confirm my previous findings at the individual level. However one rather
interesting point is clarified. Whilst both the lower and the upper sets say that the maths topics are both easier and more enjoyable than the arithmetic topics the extent to which the lower groups see maths as more enjoyable is slightly greater than the extent to which the upper groups do. And this is in spite of the fact that they also tend to see maths as less useful than arithmetic to a greater extent.

One implication of this is that it would appear that many of the lower set pupils would enjoy doing maths topics rather than arithmetic topics. And yet it is this category of pupil which tend to be given more arithmetic topics in class because it is argued that they need the practice and that, anyway, they cannot cope with the maths topics.

I am not suggesting that because pupils from the lower sets claim that maths topics are easier and more enjoyable than arithmetic topics then they are successful at them in practice. What I am suggesting is that in the past teachers have tended to be unaware of the fact that, because of its greater attraction, maths topics could, perhaps, provide a doorway to greater success in both maths and, ultimately, arithmetic topics. There does, now, seem to be a movement towards this view but it is one which is frequently viewed with suspicion and doubt.

Table D4 was calculated in the hope that it would show, at a gross level, how objective the pupils' ratings were. Objectivity, of course, can only be said to apply for the rating of easy/difficult, where it is possible to apply an independent test, and I think the results show that, on the whole, it existed as far as school mathematics topics are concerned. Two of the more able pupils were unrealistically critical of their own abilities in both arithmetic and maths topics. However, this is offset by the fact that there were also two pupils who appeared to see themselves as more able
than either their settings or their examination results would suggest.

This brings me, finally, to Appendix D Table 8 of the means of the scores across the three constructs for each of the eighteen topics and the correlations for each pair of constructs. This information does little more than point up the fact that there tends to be a significant correlation only between easy/difficult and like/dislike but it does yield one further point of interest.

I calculated the mean of the means across the three constructs for both arithmetic and maths topics and found what I already knew; namely that maths topics are seen as easier and liked more than arithmetic topics. However, if one looks only at the basic arithmetic topics of addition, subtraction, multiplication, division and area then the picture changes somewhat. The mean of the means for arithmetic topics becomes 5.0 for easy and 4.6 for like. In other words arithmetic topics now become easier than maths ones and only marginally less enjoyable.

However, if one omits angles from the maths topics using the argument that it is the calculation of angles and not their measurement which makes them so unpopular with these pupils then the mean of the means for maths becomes 5.1 for easy/difficult and 4.9 for like/dislike and once again maths has the edge.

This was not simply an academic exercise. There are certain topics, fractions in particular, which many pupils find really difficult and dislike intensely. They play an important part in examinations in the first two years of the secondary school and thus play a significant role in deciding in which sets pupils will be placed. I am not convinced of their real importance by comparison.
Chapter 6

VIDEORECORDED PROBLEM-SOLVING SESSIONS

Introduction

In Chapter three (3.4) I discussed the purpose of the video-recorded problem-solving sessions explaining that my aim was, in part, to corroborate or contradict my observations and interpretations from the earlier part of the study by the use of triangulation techniques. I was particularly concerned to discover whether or not I had made a sensible decision in choosing, as elements for the second interviews, the eighteen topics which, at that point, the pupils had studied in their mathematics lessons. I chose school mathematics topics because school is where most formal mathematical activities take place but that choice meant that I was defining mathematics in terms of the school or even the examination board rather than those of the pupils and it was possible that this may have led to distortions in the data.

I also explained that of equal importance was my plan to use the behavioural data provided by analysis of the videorecordings to provide deeper insights into the pupils attitudes to, and beliefs about, learning mathematics.

It could be argued that I had already used triangulation techniques. In the first interviews I had been looking at attitudes towards, and beliefs about, school and education in general and to do so I had elicited constructs from the pupils themselves. In the second interviews I had narrowed my area of concern to mathematics and provided the pupils with three ready-made constructs. Furthermore, I had used the data from both in a quantitative as well as a qualitative way. This fits with the description of triangulation methods by
Cohen and Manion (1985). Comparing it with its original use as a technique of physical measurement by such people as navigators and surveyors they say that:

"...triangular techniques in the social sciences attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint and, in doing so, by making use of both quantitative and qualitative data."

However, I feel that by introducing into my study videorecorded problem-solving sessions which would provide data of a quite different nature I was taking a more thoroughgoing approach to triangulation. The interviews provided oral information about pupils attitudes. Videorecordings provide behavioural information which can be used to both illuminate the oral information and to provide added data.

6.1 Why problem-solving sessions and why this sort of problem?

When, in Chapter three, I discussed the purpose of the problem-solving sessions I did not discuss my reasons for their use in preference to other ways of obtaining this data. Nor did I discuss those general factors which informed my choice of problems. I shall do so now before giving a description and explanation of the actual events.

As I have just indicated, I wanted to obtain behavioural data which would complement verbal attitudinal data. Theoretically the most natural way for me to have obtained this would have been by observing how the pupils behaved
whilst following the normal syllabus in their mathematics lessons. There are a number of reasons why I chose small group problem-solving sessions in preference.

Had the pupils remained in their tutor group for their mathematics lessons I might well have considered observing them there. By now I was known quite well by all of them and they were used to my presence in the classroom as well as in the interview room. However, the pupils were spread between six different mathematics sets. This would have made it highly desirable for me to spend some time with each set so that the pupils, including those I was not observing, would become used to me in this different setting. Multiply the number of seventy minute lessons needed for this by six and it is clear that, given that there are a maximum of three such lessons each week with all the sets being taught at the same time, the observations would have taken a long time to complete.

Even had I undertaken that rather daunting task, using videorecording equipment would have presented further difficulties. The organisational problems of setting up the equipment in different classrooms in different buildings over a period of weeks with only a few minutes between lessons to set it up and dismantle it would have been numerous. And, of course, I considered the acquisition of visual data which I could analyse later, to be of particular importance.

I would, nevertheless, have tried to find ways of overcoming problems of time and organisation had I been confident that this was a viable way of obtaining behavioural evidence which most nearly resembled that which would occur under normal lesson conditions. I felt sure it was not. I wanted to record conversations which were taking place as the work was being done and to record the behaviour which accompanied the conversations. To do so I would have to have placed the equipment close to those being observed and the
fact that this would have placed them in a different context to all the other pupils in the class would, I suggest, have been likely to produce less natural behaviour than if they were alone in a room taking part in a contrived problem solving session.

This was my main reason for taking the approach I did but before I continue a further comment is needed to put these remarks into context. Although the situation is beginning to change, much mathematics teaching is still didactic with a substantial part of many mathematics lessons being taken up by what the teacher has to say. Furthermore, when the pupils are working they are often expected to do so alone and in silence. To varying degrees this is the position for the pupils in my study. Were it the case that the problem-solving approach planned as a result of changing over to GCSE was already the norm, then I might well have attempted to observe the pupils at their lessons.

I will now turn to the general factors which influenced my choice of problems. When I began to plan this part of the study my first thought was to use problems which arose from everyday life, my argument being that this would be likely to catch the interest of the pupils and lead to reasonable solutions. Recalling the purpose of my study I quickly rejected this approach. Given that these are not the sort of problems the pupils normally encounter at school, their introductions could add to the inevitable difficulties of deciding to what extent the data is influenced by the study itself. Furthermore, since this is a study of attitudes and beliefs I was not concerned with the extent to which the pupils were capable of solving problems but in how they approached them. To this end I wanted to evoke as many different behaviours as possible including frustration, boredom and anger. In other words, although I did not want to alienate the pupils, neither enjoyment nor correct solutions
were my principle criteria. There were other more specific criteria but I will raise these as I refer to individual questions. In that way it will be possible to discuss both the criteria and the questions without having to repeat myself.

6.2 Planning the sessions

6.2.1) Arrangements for room and equipment

In 6.1 above I hinted at the potential problems of organisation when the use of videorecording equipment is involved. Fortunately I was able to arrange the recording sessions in a way that minimised organisational problems and led to no great inconvenience for anyone involved.

This part of the study took place in July of the second year. I chose this time because by then the external exams were finished and the fifth and upper sixth forms were no longer in school. This greatly reduced the pressure on room space and meant that I would have little difficulty in obtaining a suitable room which I could use each day and all day for filming.

In the event, organisation was made doubly easy for me. I had planned to borrow videorecording equipment from the university but the person in charge of the school resources centre offered me the use of the school's own equipment. Furthermore, the head of the school Languages department was kind enough to reorganise room allocation so that I could have sole use of the language laboratory for several days. This room is directly opposite the school's resources centre where the video equipment is stored so the movement of equipment was a simple matter. Also, since this is one of the more secure rooms in the school it was possible to leave the
equipment there during lunch hours. All of this made my task much simpler.

There were further advantages to having the use of the language laboratory. To provide a certain measure of sound proofing the room is carpeted and has fairly heavy curtaining at the windows. This makes it a very pleasant room in which to work but, more importantly, the sound proofing helped to improve the standard of recording.

6.2.2 Arrangements with pupils

My decision to use videorecorded problem-solving sessions crystallised during the second interviews and I visited the pupils in early June, during one of their tutor group periods, to explain what I wanted to do and why and to ask them to consider taking part. I did not give any examples of the type of problems that would be set. They seemed happy to trust my selection assuming, I imagine, that I would not choose anything that would be too taxing for them. I was aware that the utmost care was needed at this point. On previous occasions I had simply been asking pupils to talk to me and to do so in private. They had been recorded on audiotape but to people of their generation this is no great novelty. Now I was asking them to take part in problem-solving sessions where, potentially, their ignorance would be displayed to others. Furthermore, I was asking them to allow me to record all their mistakes on film.

Initially a number of the pupils were very doubtful about being videod but later, when I returned to arrange times and groupings for the recording sessions only one person, a very shy girl, decided not to take part and thus to drop out of the entire study.

I think a number of factors played a part in the high
involvement rate. The pupils' good natured willingness to be involved and to help me was of primary importance as was, I suspect, their desire to try something new and different. Being on film is still a sufficiently rare experience to excite the interest of most people. My contribution was an enabling one. I believe that by allaying their fears about possible disadvantages I made it possible for the majority to do what they rather wanted to do anyway.

I attempted to allay their fears firstly by making it clear that their abilities were not being tested. My explanation of my aims was basically the same as that given in this chapter. Secondly, I made it clear that the video-recordings would not be seen by anyone else in the school. They were concerned, not about strangers seeing them but about other people who knew them. Thirdly, although I stipulated that I wanted them to work in groups of three, I explained why and stressed that they themselves must decide on the groupings. Finally, I did not press them for an immediate decision but suggested that they discuss it among themselves and with their parents and group tutor and let me know their decision when I returned.

I do not, of course, know which of these factors was most important, if any. I know only that when I returned the majority were eager to take part and quite excited about doing so. I was very relieved because had a significant minority refused I would not have continued with this part of the study. I had already decided that when I finally brought my data together after each part of the study had been analysed, I would include information from only those pupils who had taken part at all stages.

Two weeks later, during their next tutor group period, I returned to hear their decision and to plan groupings and times. A situation occurred at this time which is worth mentioning because it illuminates the importance of paying
great attention to the needs and wishes of those taking part in research particularly, perhaps, if they are young people or children.

After my previous visit, in conversation with the group tutor, I remarked on the fact that, ideally, I would like the problem-solving groups to be composed of a mixture of boys and girls and people from different sets rather than them being simply friendship groups but that I supposed the latter would be what I would have to settle for. He suggested that he knew the members of the group well enough to be able to plan groupings that would work on all those counts. Having already promised the pupils that the decision would be theirs I decided to compromise by showing the list to the pupils and asking if they approved it.

The outcome was almost disastrous. When I brought out the list, twenty nine people had already agreed to be filmed and were showing great interest and enthusiasm. They appeared not to have made any clear decisions about which people would work together. I explained what their group tutor had done and why and they were quietly receptive. I read out the list and in place of a friendly group I was faced with an angry mob. Many were quite adamant that they would refuse to join in rather than have to work with those they had been grouped with. I hastened to point out that this had been only one possibility and urged them to form groupings of their own.

Peace was restored and there ensued a rather long and complicated series of interactions between members of the tutor group, which resulted in the formation of nine groups of three and one of two. How I wish I could have videorecorded all the details of that scene. I am sure it would have provided much valuable material which would have illuminated what I had already learned and was yet to learn about individual pupils.

As I had feared, boys and girls had not mixed. There was
only one group of two boys and one girl. The girl is unusually confident and considerate. She was one of four friends who all wanted to be together and when she noticed that the two boys were on their own she offered to drop out from the negotiations with her friends and join them. This really was an altruistic act because the boys both tend to be picked on by other members of the group. Her behaviour made matters easier for five other people. Unfortunately, as she told me during our final interview, she did not particularly enjoy working with the boys. She likes to cooperate and, as my recorded material shows, they were not very good at this.

A rather sad event took place at this time. It concerned a remedial pupil whose removal from the study I referred to in chapter three (3.7.4) and again in chapter four (4.1.1). Fortunately, as it turned out, he was absent from school when the groupings for the problem-solving sessions were negotiated. I raised the question of which grouping he would join, but every member of the tutor group refused to work with him. They all found him too noisy and aggressive. I had no wish to upset the boy so when I saw him later I was somewhat 'economical with the truth' and suggested that, since the groups had been formed in his absence, he might like to bring to the session two of his friends who were not members of the study group. He happily agreed and I videorecorded them but with no intention of including the material in my study. As it turned out, at the time of the third interviews, the boy was absent so the problem resolved itself without hurt to anyone.

To my delight I was mistaken about the ability groupings. Even though I expected these to be mainly friendship groupings I had expected to find that pupils would tend to join only with those from their own set but this was not so. No group had members from only one set and, if once again we consider just two groupings, the two top sets and the lower
sets, then five of the ten groupings crossed the divide. Not by far though. One group had members from sets one, two and three. Two groups had two members from set one and one from set three. The duo had a boy from set two with a boy from set four. Only one group showed a fairly wide spread having a set one boy with two set four boys. Nevertheless this was encouraging because it meant that I would be able to observe interaction on problem-solving between people who were, according to examination results, of quite different levels of ability.

No doubt the whole business of forming groups would have been easier and less time consuming had I accepted groups of two or four. I chose not to for three reasons. One is that I did not want pairs. I have observed that groups of four tend to break up into two groups of two and two people tend to explain to each other rather less than when there are more people trying to make their point. Secondly, there is a greater opportunity for each person to have their say when the group is as small as three. The final reason had to do with videorecording. By placing one person at the far end of a table with one on either side there was a good chance that the camera would record all their behaviour. If there were more people they would start to obscure each other.

In retrospect all but two of the groupings worked well and I do not believe this level of success would have been achieved had the pupils not made their own choice. The two boys who worked as a pair rarely spoke in spite of my constant efforts to stimulate conversation. I had suggested that they invite someone from another tutor group to join with them for the session but they refused. They were a rather shy and very private pair who showed no inclination to mix further. I felt I must respect their wishes.

The second grouping which did not work very well had experienced a rift between two of its members on the day
previous to the problem-solving session and it was only the great efforts of the third member which persuaded them to even enter the room and join in the study. It is difficult to judge how much this affected the outcome because one of the two girls concerned was very shy and unsure of herself anyway and it may be that she would have been somewhat uncommunicative whatever the situation.

6.3 The problems

My approach to finding problems was rather unscientific. I worked on the basis that I would recognise what I wanted when I saw it rather than deciding in advance what I was looking for. I looked in journals which were aimed at those who teach mathematics but I also turned to the Nuffield Mathematics Project Problem Sets (1969) and it was from here that I got six of my problems. Three other problems came from the journal 'Mathematics in School' (May 1986) and the final one I made up myself.

For convenience the problems are listed together in Appendix E but I will write them individually here giving their source, (Nuffield will stand for Nuffield Mathematics Project Problem Sets and Journal will stand for Mathematics in School) and notes about my reasons for including them and why they came in the order they did. However, where a problem is dependant on a diagram I will summarise it and leave the reader to turn to the appendix for full details.

The reasons I give for each problem are the ones which made me select that particular one. Any individual problem may have qualities mentioned for other problems. To avoid tedious repetition I will not necessarily refer to them. It should also be borne in mind that all questions were there to
serve the more general purposes referred to at the end of 6.1 above.

PROBLEM ONE. (Nuffield) Mrs. Chalmers is buying Christmas presents for her seven children to give to one another. Each child gives a present to each of the others. How many presents must she buy?

The simplest of the problems and chosen to put pupils at their ease. They could, hopefully, cope with it while at the same time getting used to being filmed and to the situation in general. But, while quite simple there is enough there to stimulate conversation and to make clear the type of topics involved in this session.

PROBLEM TWO. (Nuffield) My age this year is a multiple of seven and next year it will be a multiple of five. If I am not yet fifty but I am older than thirty how old am I?

Still a fairly simple problem, so placed near the start of the session. Really quite dependent on a knowledge of tables, so what will happen when pupils do not know them? A need to keep a number of things in mind. Is this the sort of thing that they do? In particular, will they check that they have covered these things when they have an answer or just carry on?

PROBLEM THREE. (Nuffield) If each of four people shake hands once with each of the other three, how many handshakes will there be? How many if there are five people? Is there any easy way of working out the number of handshakes for any number of people?

A problem which needs not only a methodical approach but where some use of pen and paper would be helpful. However it can also be solved in a practical way by actual handshaking. Who will do what? Will anyone look for a formula or even realise that this is a useful thing to do? Placed here because it can be resolved in a number of ways and, therefore, should not be very frustrating.
PROBLEM FOUR. (Journal) The diagram (see Appendix E4) shows a solid cube made up of smaller cubes. It is accompanied by:—This solid cube is made up of 125 unit cubes. How many unit cubes have three faces exposed?; two faces exposed?; one face exposed? To help you, one of each type of exposed face has been shaded in.

An awkward problem to answer without having a cube to handle. Quite likely to lead to frustration and boredom and to giving up. Placed at this point for that reason. I wanted to include frustrating problems fairly early on while pupils were still fresh so that if they did get frustrated and/or give up it would not be because they were tiring at the end of the session.

PROBLEM FIVE. (Journal) Accompanying this problem were six sets of four small triangles each of which had a number at each edge (see Appendix E5B). The triangles were cut out from the journal and mounted on cardboard for easy handling. The problem card also showed examples of another such set of triangles both separately and made up into a larger triangle.

The problem card stated:—The problem is to arrange four triangular tiles to make a large triangle like this (see Appendix E5A). However, wherever two triangles touch each other along an edge, the number on those two edges have to be added together to make a 'Touch Total'. The three touch totals made in the large triangle must all be the same.

There follows an example of how to do it and the touch totals that have to be achieved for the first five sets. For the sixth set the Touch Total has to be worked out.

Included here partly to calm pupils who have become frustrated by the previous problem and to give all pupils a problem to solve physically. Another reason is that this is a problem where pupils could easily divide the work amongst them or deny others access to the triangles instead of cooperating. Finally I wanted to see if anyone would begin to
look for a pattern or some logical basis for solution rather than simply using trial and error.

**PROBLEM SIX.** (Nuffield) Mrs. Brown breeds dogs. At present she has eleven, of which seven are spaniels and eight are puppies. How many spaniel puppies is it possible for her to have?

Included because it is an open ended question with a number of possible answers. Furthermore it is badly worded and full of ambiguities. I wanted to see who, if anyone, would consider a number of different possibilities, who would settle for one and who would give up. Also included because a Venn diagram could be used in its solution and the pupils had already learned to use these. Left until this point because by now the pupils should have had sufficient time to get used to the situation, the camera, my presence and the task. Hopefully they would easily get lost in discussion and forget other factors around them.

**PROBLEM SEVEN A.** (Nuffield) A boy has two bags, two red marbles and two green marbles. He places one red marble and one green marble in each bag. If he now chooses one bag at random and then draws out of that bag one marble at random, is it equally likely to be red or green? If he repeats the experiment fifty times, about how many times do you think he is likely to draw a green marble?

Included because none of the pupils have been taught about probability but that is a topic which crops up a great deal in everyday life. I wanted to find out if this problem would be approached in what has come to be known as a ‘Folk Maths’ way. Included here because if the pupils were going to be relaxed and willing to experiment it should have happened by now.

**PROBLEM SEVEN B.** (Nuffield) Suppose now the boy places both red marbles and one green marble in one bag and the other green marble in the other bag and repeats the actions
just described: are a red and a green marble equally likely to be drawn now? If he repeats the experiment fifty times, about how many times do you think he is likely to draw a green marble?

A continuation of the previous problem. They were not given together because it seems unlikely that this one could be solved intuitively. Had the pupils read straight through both parts of the question the difficulty of this part could have deterred them from considering the first part. Included to find out if pupils would use the earlier material to help them here and to see if diagrams would be used to help in its solution.

**PROBLEM EIGHT.** (Journal) Accompanied by a diagram (see Appendix E8) of a pyramid type shape built from unit cubes. The card says:- The bottom layer of the pyramid contains 5 x 5 = 25 unit cubes. The next layer 4 x 4, the next 3 x 3, and so on. How many cubes are hidden from the outside? How many cubes have only one face, two faces, three faces, four faces, five faces visible?

As with problem four this problem was included to frustrate. It was placed at this point to find out if those who were not frustrated or bored earlier would become so towards the end of the session. This is a particularly awkward one to do from a picture and, therefore, potentially more frustrating than number four. There was a much greater chance of the situation deteriorating but at this late stage in the session I felt it was a chance worth taking. I also felt that by this time there might be a greater possibility for me to divert pupils from the question if a deterioration did take place.

**PROBLEM NINE.** (My own question) I bought two chocolate bars and three packets of fruit gums for 76p. My sister bought three chocolate bars and one packet of fruit gums for 65p. Now my father says he will pay for the chocolate bars
and my mother says she will pay for the fruit gums but neither my sister nor I can remember the prices. See if you can work out the price of a chocolate bar and the price of a packet of fruit gums.

This was the final question and I did not expect most of the groups to have time to attempt it. It was included merely to find out who, if anyone, would see the necessity of searching for a method rather than using trial and error.

6.4 Pilot study

This is a pretentious label for the one session I had with pupils who were not in the study. I had decided on this particular method for this part of the study and, given the problems of acquiring a room and setting up the equipment, I decided that one session in the morning prior to starting the actual study sessions in the afternoon would be sufficient. All I needed was to iron out problems of organisation and time and to pinpoint other potential difficulties.

I invited three pupils who had taken part in previous pilot studies to help me once again. I chose two boys and one girl whom I knew to be particularly able and articulate because I felt confident that they would not only identify potential problems but would also be eager to discuss them with me and suggest changes.

In the event, organisation and timing presented no problems and the three pupils thoroughly enjoyed themselves. They were somewhat unsure about the last problem because, as they were honest enough to admit, given that they found the problem difficult it was unlikely that any of the study pupils would be able to cope with it. We discussed omitting it for fear that it would be too threatening but finally we
all agreed that this was unnecessary providing it remained at the end.

I did decide to act on the one suggestion they made. This concerned my own involvement in the situation. My presence was necessary because of the equipment but I had intended to sit and work at the other end of the room and to resist involvement. I did this with the pilot study trio but they felt that I had taken it too far. They said that they quite understood my determination to reject involvement in the discussions but that my refusal to respond to requests for information seemed boorish and provocative. Later experience demonstrated that I was wise to follow their suggestion.

Needless to say, there were actions I took as a result of my observations of the pilot study group. However, they were not of great importance and I will refer to them later as need arises.

6.5 The problem-solving sessions

6.5.1 Setting the scene

Each session took approximately one and a quarter hours this being slightly longer than the length of a lesson. Several lasted longer because the pupils became very interested and wanted to discuss the problems with me after they had finished. I allowed interest, or the lack of it, to determine the ending of each session.

The pupils sat around the teacher's desk, which was a table approximately three feet by five feet in dimension. One pupil sat at the narrower side facing the camera and the others sat one on either side. In the one instance where there were only two pupils one sat at the shorter side and the other on his left.
The chairs were already in place when the pupils entered the room, as was the camera, so I allowed them to decide who would sit where. However, before they sat down I explained that the one in the middle would be wearing the same microphone they had each worn during their interviews. By providing all necessary information in advance I hoped to avoid anyone either facing the camera or wearing the microphone when they felt particularly uncomfortable doing so.

One reason I had decided to use audiotape recordings as well as video was that I wanted to ensure that all conversation would be recorded. When people are working together they will often lean towards each other and speak in low voices or look down at what they are doing. In either case the words might be muffled to the camera microphone. By recording the conversation by way of a lapel microphone these difficulties were overcome. When I came to listen to both sets of tapes it was clear that many remarks would have been completely lost if I had not used both methods.

I had another reason for dual recordings. It is much simpler to transcribe from audio tapes than it is from video tapes. I was still presented with a greater problem than I had when I transcribed the interviews. Then there were only two voices and one of those was my own. From the problem solving sessions I was, for the most part, faced with deciphering the words of three people of the same sex who were frequently speaking at the same time as each other. I overcame the problem by transcribing the conversation from the audio tapes and then using the video tapes to check who had said what. When I couldn’t be certain, from the audio tape, just who was speaking at a particular point it was usually possible to decide by looking at lip movements on the video tape. Occasionally, when heads were down, even that was
not possible and then I had to use the context to help me to make a decision.

I had arranged the monitor in such a way as to ensure that the screen would not be visible to the pupils. It seemed possible that they might tend to forget about the camera if its presence was not constantly being drawn to their attention. However, before settling down to work I encouraged each pupil to come in turn to view the other two pupils on the monitor. I hoped this would take some of the mystery out of the proceedings and perhaps allay any fears they might have. I used this time to reiterate and stress the fact that these recordings would not be seen by other people at school, either staff or pupils.

Everything the pupils needed for the task had been laid out ready on the desk and the audiotape recorder was on a chair at the side. I had hand-written the problems in green ink on pale green cards which I then covered with a transparent material to provide a clean and pleasing finish. These, together with one notepad and one pen were in a pile at the pupil's end of the desk. I had placed the triangles for problem five at the end of the table near to the camera to avoid premature interest from the pupils.

I included only one notepad and one pen because I wanted the pupils to work together and I believed that this would be less likely to happen if they each had a notebook and pen. Furthermore, I wanted maximum discussion and minimum writing and I believed that this would be more likely to occur if only one person could write at a time.

Before they studied the first question I reminded them that I was interested in how they interacted with each other and with how they went about solving the problems rather than with whether or not they got them right. I asked them to cooperate with each other rather than trying to solve the problems by themselves and asked if, when they thought they
could see a solution, they would explain it to the others rather than just telling them the answer. I explained that this would help me to understand what was going on. I asked them to try to get a consensus before moving on to another part of a problem or to another problem and I also pointed out that although the notepad was there for their use, if they did not also discuss what they were writing, there was no way of recording their meaning. Finally I explained the order in which I wanted them to work through the cards, indicated that the purpose of the triangles would become obvious when they reached the relevant card and explained that I did not wish to be involved, except on points of information.

6.5.2 The sessions

Once the pupils had settled down to work I repaired to the back of the room and, for the most part, sat at a desk and worked. Every group asked for information at some point and there were a few people who were more ready to turn to me, rather than the other members of their group, as a first rather than a last resort. I discouraged this because of its potential effect on group interaction and cooperation but it did provide some useful information about attitudes and beliefs.

In the same way it was useful to note other differences in behaviour towards me. There were individuals who seemed to need my approval of their ideas before they could feel confident in them. Others completely ignored me unless I spoke first and there were those who kept contact with me throughout by means of witty remarks and amusing, or simply friendly, comments.
Again because of its potential affect on the group, I tried to discourage the first type of behaviour but I did nothing about the friendly comments because there was never a tendency for the situation to get out of hand. The comments were good natured and appeared to be based on sociability and I could see no good reason for actively discouraging them.

There were points of information which I supplied to each group at points during the session. As a result of observing the pilot study group I asked them to imagine that they could take hold of the cube in problem four, turn it around and examine it from all sides. I did the same with problem eight where more cubes are involved. And finally, when they came to question five I went over to the desk and handed the triangles to them.

There were other occasions when I interrupted in an unplanned way. Two examples should suffice. Not everyone, when they did problem two, knew the meaning of the word multiple. Some who did not know asked but others did not and when it became clear they did not understand I explained the meaning to them. And when I did this I endeavoured to find out why they had not asked me.

There were some occasions when, even after prolonged discussion, a group still did not understand what a problem was about. This was the case particularly with problems four and five. Once it was clear they were not getting anywhere I interrupted and explained as much as was needed to help them on their way. I felt justified in doing this because I was not concerned with ability to solve problems.

Once again these events provided data about the behaviour of individuals which could be used to illuminate what I had learned in other ways and to provide pointers to individual attitudes and beliefs.

After each group had finished all ten problems or, in one case, when time was obviously running out and I had called a
halt, there was a debriefing session. I asked the pupils to
tell me how they had felt about doing the problems and
whether or not they had enjoyed the session and how they had
felt about being filmed. I also asked them if they thought
the exercise had been mathematical. I was, of course hoping
for more illuminative data from these debriefings but I also
hoped to find out whether or not I should be cautious about
the data because of how the pupils had reacted to the
situation.

In exchange I tried to give some feedback to the pupils.
At its most simple I was able to provide quite a lot of
delight and hilarity by rerunning part of the video film so
that they could watch themselves on television. The other way
I achieved feedback was by answering their questions about
the problems.

During the pilot study there were occasions at the end of
solving a particular problem when the pupils involved wanted
to stop and discuss their conclusions with me. I asked them
to continue and promised to return to their points of concern
at the end of the session. We did and that seemed to provide
them with a lot of satisfaction.

Bearing this in mind I discussed this matter with each
group at the start of the session. I promised that if they
would just work their way through I would return to each
problem and answer their questions about it at the end of the
session, if that was what they wanted.

What began merely as a useful way of saying thank you to
the pupils for working hard and giving up their time turned
out to be a valuable source of data. There were those who
were interested only in how well they had done. Many wanted
information about that which they had not fully understood
and with some it seemed as though they would have been happy
to indulge in a blow by blow account of the whole session. A
few seemed really puzzled at the notion that anyone would
wish to reflect on that which was over and done with. They watched themselves on television and left.

6.6 Analysis

6.6.1 Qualitative data

The audio tapes were transcribed to provide a verbatim record of the conversations. The transcripts were used as an aid in interpretation of the videotapes but they were also used, after being further reduced, as an aid in identifying categories. I expected some of these categories to be relevant specifically to the solving of the problems which had been set and others to be more general and either contributing to the basic stock of categories built up from the two interviews or providing the means for illuminating or corroborating the existence of categories detected earlier.

Analysis of the video tapes was more complex and time consuming. To begin with I simply watched each tape right through to gain an overall impression of what was happening. I then watched each tape again but as I did so I made notes of any impressions I had gained. Finally I watched each tape a third time but on this occasion I made notes about each pupil’s behaviour as each question was answered and I also made similar notes about the interactions of each videorecorded group.

I hoped that this would provide me with data which would illuminate both the conversations from these sessions and the data from earlier interviews. I expected that the value of most of what I would learn would lie in its contribution to the building up of a profile of each member of the study. By comparing this profile with allocation to sets and actual performance in examinations, I hoped to identify clusters of
attitudes and beliefs which accompany either success or failure in school mathematics.

As the previous paragraph indicates, I was, in a very general way, well aware of the sort of behaviours I was looking for. To be more precise, I was hoping to encounter behaviours which could be said to accompany certain attitudes or beliefs but before watching the videorecordings I had no clear ideas of what these behaviours would be. I was expecting to recognise them as they occurred.

I was well aware of the dangers inherent in this approach. To label a behaviour as belonging to a certain attitude or belief as I saw it occur would be to blind myself to other possibilities. In an effort to overcome this I decided to undertake one further level of analysis.

Using the impressionistic notes I had made on the second viewing of the video tapes together with my more detailed notes from the third viewing, I produced sixteen categories of behaviour which I believed I had encountered sufficiently often to be worthy of further study. I drew up a table for each of the videorecorded groups and, watching the videorecordings once again, I made note of each incidence of every one of the behaviours by each individual pupil.

As a further check I related the behaviours to the particular problem which was being solved at the time. I did this in an effort to identify any behaviours that might have been elicited by the nature of a problem rather than being related to the attitudes or beliefs of individual pupils. If there were any particular behaviours that could be attributed to all or most of the pupils when they were working on one particular problem then I would ignore those examples of that behaviour.

When I had collected this data for all of the groups I compared each set of findings with the rest and concluded that three of the categories should be eliminated. I shall
list them here together with my reasons for eliminating them and I will not refer to them again.

The first category concerned the displaying of frustration and the second the displaying of puzzlement. I decided to leave out both for two reasons. The first was because of the subjectivity involved in the labelling of these behaviours and the second, and perhaps more important reason, was because there may have been cases where pupils felt frustrated or puzzled but did not clearly show it. The third category had to do with being good natured. Although the behaviour of all the pupils appeared to be good natured in the beginning, I had the impression that some pupils became less good natured as the sessions wore on. I still retain this impression but when I examined the behaviour during the solving of each individual problem in the way which I have explained above I did not detect it. A probable explanation is that where the behaviour did deteriorate during the session it was so gradual and relatively slight that it did not show up at the unit level.

The other thirteen categories are as follows:-

1) Not listening carefully to what other pupils had to say about a problem.
2) Not discussing a problem with the other pupils or pupil involved.
3) Discussing a problem without pause for thought.
4) Not writing anything down.
5) Not attempting to explain their ideas to the other pupils.
6) Not actually reading a problem for themselves.
7) Not re-reading a problem as the discussion progressed.
8) Deciding on a solution before a problem had been fully discussed.
9) Not taking part in the efforts to solve a problem.
10) Turning to me for information or for my opinion.
11) Making remarks which were totally irrelevant to the solution of a problem.
12) Behaving in a way which was not relevant to the task in hand. For example, turning to look around the room; drawing; talking about some other topic; reading a problem other than the one under consideration.
13) Deciding to give up on a question before deciding on a solution.

I have defined each of these behaviours negatively because only a minority of pupils behaved in such a way and that was why my attention was drawn to the behaviour. However, in the building up of a profile of each pupil the absence of such behaviour may be equally important. When I drew up the tables and made a note of the incidence of each behaviour I noted both its presence and its absence.

Before listing the categories I explained that I had developed them from impressionistic and individual data and then examined each videorecording for examples. By recording the behaviour and then evaluating it out of context I had hoped to avoid premature labelling of any one behaviour as belonging to a particular attitude or belief. I had also hoped that I might be able to arrive at some general conclusions about categories and thought that I might be able to draw up a table of the incidence of behaviours and discover if they were exhibited to any greater degree by pupils in lower or higher sets.

In fact I did go so far as to draw up such a table, noting the incidence of each behaviour in its negative form by any one pupil and doing this on a quantitative basis so that I could see not only that the behaviour had occurred but how frequently. But then I realised that I was falling into
the quantitative trap and producing numbers with no real meaning behind them.

A glance at the categories and two examples by way of explanation should be sufficient to demonstrate why this is the case. It rapidly becomes clear that the same behavior could accompany different attitudes and only the context could suggest which ones would be the most probable. For example, the decision to give up on a question before deciding on a solution could be taken very quickly and without much thought and the context might suggest a tendency to believe that if one cannot immediately see a method for solving a problem then one probably never will. On the other hand the decision could be made reluctantly and only after much effort towards finding a solution. In both cases the behaviour is informative but only at the individual level. Generalisation can only lead to loss of meaning.

A further reason for the lack of value in generalisation about individual behaviours is that it is frequently important to look at the behaviours in relation to each other. For example, I give 'not actually reading a problem for themselves' and 'not re-reading a problem' as negative behaviours but if the pupil concerned had been making notes about the problem as someone else read it out then they may have had no need to read the problem again.

It would have been reassuring to have behaviours which could be compared across the whole study group but, for the reasons just given, I decided to confine the use of this data to individuals and to use it as background material to confirm or refute any conclusions I might reach about them on the basis of data from any of the three interviews.
6.6.2 Quantitative data

I also performed a different type of analysis of the videorecordings. I have said, on a number of occasions, that I was not undertaking this part of the study in order to discover how accurate pupils were at problem-solving but, nevertheless, I acquired that data in the course of my enquiries and so I used it.

To simplify matters I copied the videorecordings in such a way as to have all examples of one question together. This made it possible for me to take each question at a time and analyse and compare the ways in which pupils had approached each question and their relative degree of success in finding solutions.

Analysis of this data was very difficult. The pupils were not working alone and there was the problem of deciding to whom an answer should be attributed. There was also the problem of deciding where to draw the line over which responses should be included and which ignored. I felt that a lot of interesting work from pupils would be lost if I considered only the correct answers. A good example of this comes from the first question. When I set it this seemed to be very straightforward and I assumed that the main reason pupils might get the answer wrong, apart from any problem over multiplication tables, would be because they forgot that the children had to give only six presents. I assumed that some would decide that the answer was seven times seven. This did occur but, the reason why a few pupils got the answer of forty nine was because they decided that the mother had also to give a present to each child. And this did not simply arise from a misreading of the question but from a cultural confusion. Even after they had re-read the question several times and indicated that they were doubtful whether or not the mother should be included, cultural matters dominated.
After all, mothers do buy Christmas presents for their children. In this case the pupils were well aware that the answer would be forty two if the problem was concerned only with the giving of presents by brothers and sisters. Had I ignored this fact I would have been ignoring the essence of the problem.

Similarly, to have considered only accuracy in putting together the triangles for touch totals would have been somewhat pointless. In most cases accurate results seem to have been achieved by trial and error and a certain amount of luck must have been involved. Certainly I could not always identify any strategy where results were achieved very quickly. It was only when they were not getting anywhere that people began to discuss ways of approaching it. Consequently I ignored the first five triangles, which all of the groups solved with relative ease, and concentrated instead on the sixth one where the touch total had to be worked out.

My general approach was as follows. I allocated marks to each problem on the basis of criteria internal to each problem. I then rated each group as a whole according to their results. Finally I analysed the protocols of each group for indications of each pupil's contribution to the success of the solution and weighted the individual results accordingly. To provide an example, the results for one question are shown in Appendix E Table 1.

Inevitably, a degree of subjectivity is involved in my conclusions but I would argue that having the videotapes to view does help considerably in maintaining a degree of objectivity. For example, when discussing the number of handshakes in problem three, two or three people may have been involved in putting forward arguments which lead towards a conclusion but it is quite probable that one person would reach the answer first. If the answer was correct I would rate the others according to their previous contribution and
according to the extent to which they demonstrated an immediate grasp of the facts. My conclusions about this were drawn from comments, further suggestions, questions and also from facial expressions such as frowns and smiles.

6.7 Conclusions

The most interesting, or at least the most unexpected, conclusions arise from the answers given to the problems. I had rather taken it for granted that the pupils in the upper sets would consistently display a greater degree of accuracy than would the pupils in the lower sets. This was not entirely the case. The results, set out below, indicate that some of those in the lower sets performed as well as their so-called betters in the higher sets.

The numbers below add up to twenty nine rather than the twenty eight pupils in the overall study. This is because, for this chapter only, I have included the pupil who left before the final interviews took place. I included her because this was a group exercise. The terms HIGH, MEDIUM and LOW refer to the individual ratings for accuracy discussed in 6.6. above.

<table>
<thead>
<tr>
<th>SET</th>
<th>NUMBER IN SET</th>
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<th>MEDIUM</th>
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<td>1</td>
<td>9</td>
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<td>9</td>
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The question arises as to why these results occurred. In the first paragraph of this chapter I said that one reason
for doing this part of the study was to corroborate or contradict observations from earlier parts of the study. In particular I was concerned that, by choosing school mathematics topics as elements for the basis of the second interviews, I was defining mathematics in terms of the school or the examination board rather than in those of the pupils. I was aware that it was possible that doing this may have led to distortions in the data.

I hasten to say that when I felt those concerns and decided on the problem-solving sessions I had no idea that I was going to make these particular findings. I had given no thought to the matter. The sessions were intended only as a vehicle for obtaining behavioural data just as, in the second interviews, asking pupils if they found topics easy or difficult; if they liked or disliked them and if they believed them to be useful or not was intended as a vehicle for obtaining data about attitudes and beliefs.

In retrospect I realised that I now had two types of data about attitudes to mathematics. The first was explicit and arose from a discussion of topics in mathematics, which I divided into two categories, 'arithmetic' and 'mathematical'; the second was implicit and arose from doing mathematics. The ratings given to mathematics topics by the pupils during the second interviews showed a fairly good fit between scores and mathematics sets. The ratings earned by the pupils in the problem-solving sessions did not. The behaviour of some lower set members indicated both a higher level of ability and a higher level of enjoyment than I would have expected.

The explanation lies, I would suggest, in the fact that each type of data is based on different concepts of mathematics. The first used an arithmetic and reproductive approach which inevitably involves a large amount of algorithmic learning. The second uses the concept of mathematics as problem-solving. The first, predictably,
correlated quite well, at a general level, with the overall setting of the pupils. The second did not.

Taken together, at the end of the analysis of the problem solving data, these results suggest that the term 'Attitudes towards and beliefs about mathematics' is too general. This may be particularly the case as far as attitudes are concerned. It may be necessary to separate attitudes towards routine work and attitudes towards problem-solving. These attitudes might affect pupils' work and there may be lessons to be learned from this.

A second set of conclusions drawn from these results is not relevant to this particular study and will be given only passing reference here. It has to do with group interaction in the learning of mathematics.

The introduction of GCSE has led to a determined search for ways of giving a more prominent place to problem-solving in the mathematics curriculum. It is likely, as is already the case in many subjects, that this will lead to a greater use of group work than now occurs. The videorecorded data from the problem-solving sessions in this study indicate the potential problems involved.

The use of group work can be looked at in two ways. One could argue that for optimum progress there are those individuals who should or should not be allowed to work together. Or one could argue, as I would be inclined to do, that, given the advantages of working with people in whose company one feels at ease there are certain ways of working and interacting with others which should not only be encouraged but for which training should be given. And within those ways of working and interacting are hidden many attitudes and beliefs.
Chapter 7

THE THIRD INTERVIEWS

Introduction

The third interviews, which I shall discuss in this chapter, can, perhaps, be said to have provided the main data for this study. The first interviews provided background information on each pupil, made it possible for the pupils and me to get to know each other and gave them the opportunity to develop some ideas about my methods and aims. The second interviews gave more detailed information about the pupils' beliefs and attitudes with regard to school mathematics and provided a number of categories which were referred to by all or most of the pupils in the study. Following this the videorecorded problem-solving sessions were undertaken to provide corroboration or contradiction for my observations from the earlier part of the study and to provide deeper insights into the pupils' beliefs and attitudes referred to above. Now, for the third interviews, using data from the second interviews, I was in a position to ask the same questions of all the participants in the study whilst at the same time being confident that those questions derived from the participants' views of what was important and not merely what I thought mattered.

The purpose of the third interviews is, as I have already suggested, the essence of this study. I hoped to find out if there are any beliefs and/or attitudes which are held more by those who are successful at school mathematics than those who are not and vice versa.

Before I began the study I would have posed that aim somewhat differently. I would simply have referred to pupils
who were mathematically able and those who were not. However, as I argue in my conclusions to chapter 6 (6.7), the data from the second interviews combined with that from the videorecorded problem-solving sessions suggests that one cannot take for granted that in all cases there is a strong correlation between ability, or lack of ability, in mathematics and success in school mathematics. Consequently my hypothesis is somewhat changed.

I would stress that given the nature of this research this change is quite legitimate. The use of the Grounded Theory approach to research allows for changes in hypotheses as analysis of the data provides new insights into the problem. Indeed, this is the very purpose of the Grounded Theory approach (Glaser & Strauss 1967).

The data from the categories referred to by all or most of the pupils during the second interviews was analysed and used to draw conclusions which were detailed in chapter five. It should be recalled (5.5) that, using the settings to which the pupils had been allocated on the basis of examinations and term work, I was able to compare the pupils with regard to these categories.

There were, however, a number of categories produced which were referred to by smaller numbers of pupils. I said, at the beginning of 5.5, that these were incorporated as questions to be put to the pupils in the third interviews and that is why I am able to say here that the questions in this part of the study derived from the participants' own views.

There was a further reason for the third interviews. I wanted to discuss, with each pupil, the conclusions I had drawn about them as a result of analysis of the first and second interviews and the videorecorded problem-solving sessions. This was because I felt that their views of my interpretations were as important as my own. I wanted them to be able to say, firstly, if they thought I was wrong or,
secondly, if I had been right at the time but that the situation had changed.

7.1 The development of the questions

7.1.1 Structuring the questions

It was my intention to organise the third interviews so as to be, as far as possible, similar to the earlier interviews. What I mean by this is that although I would now be posing specific questions I wanted to maintain the informality of the earlier interviews and to encourage pupils to develop their responses in an undirected way. In order to achieve this I decided to use open ended questions.

Cohen and Manion (1985) quote Kerlinger as describing open ended items as:

"those that supply a frame of reference for respondent's answers, but put a minimum of restraint on the answers and their expression."

They add that:

"other than the subject of the question, which is determined by the nature of the problem under investigation, there are no other restrictions on either the content or the manner of the interviewee's reply. Open ended questions have a number of advantages: they are flexible; they allow the interviewer to probe so that he may go into more depth if he chooses, or to clear up any
misunderstandings; they enable the interviewer to test the limits of the respondent's knowledge; they encourage cooperation and help to establish rapport; and they allow the interviewer to make a truer assessment of what the respondent really believes".

To this I would add a further comment. As a result of many of the factors mentioned by Cohen and Manion the questions posed initially need not be so clearly unambiguous as to be trivial. It is possible, as they imply, for the interviewer to discover what meaning the question has for the interviewee and to clarify the intended meaning of the question as posed. An added bonus is the possibility that further insights will be available to the interviewer as a result of the created need for the negotiation of meaning.

This approach seemed tailor made for my study both for the atmosphere it could create and for the desired outcomes. I was very aware that, as a result of my asking specific questions, the pupils might feel less involved and, perhaps, less important than they had previously. As far as possible, I wanted to avoid this and at the same time to ensure that the questions I posed would not be restrictive.

7.1.2 Choosing the questions

As a result of the second interviews I had more than twenty eight hours of dialogue. Even though the discussion centred on mathematics as learned in school it was inevitable that in that time twenty eight individuals would produce a large number of categories, many of which could be incorporated into interesting questions. Clearly I would be unable to use
all the categories and so selection was needed.

My main priority for the decision to develop a question was the number of pupils who had referred to the particular category from which it arose. This seemed to be an obvious choice since I had gone to some lengths to determine what the pupils themselves considered to be meaningful and it seemed likely that the larger the group which considered it important enough to mention, the more likely was it to be significant.

On occasions I found myself fighting my own reluctance to include certain questions because they seemed unlikely to provide much in the way of useful information. I did include them, for the reasons I have just outlined, knowing that if they were uninformative this would probably show up, in the data, as questions which did not produce responses which discriminated between the more able and the less able pupils.

One such example was, 'Do you find any maths topics fun to do?' With this one I was proved correct in that it did not discriminate but another question about which I was doubtful was one which proved me wrong. That was, 'Do you think that maths needs to be taught in a different way to other subjects?' I had expected everyone to say yes but they did not and, in fact, I found their actual responses quite surprising.

Questions emanating from categories produced by very few pupils were selected on the subjective grounds that I considered them likely to be informative for this study. I would add, however, that this was done in the light of the background data which I had gained from the interviews and the problem-solving sessions and, of course, in the knowledge that analysis would indicate if the questions did not produce discriminating responses.

Two questions arose from categories which, as I mentioned in the introduction to this chapter, were referred to by all
or most pupils and were used at that time to draw conclusions and compare pupils. The questions were suggested by the categories. I will explain this further when I discuss the questions in detail.

7.1.3 The questions

There were forty four questions in all and I explicitly asked each of them at each interview. For convenience I will list them here but I will make no further reference to them until I discuss the interviews themselves. There I will make any explanatory points which seem necessary.

The questions were as follows:

1) Do you like cooperating with other people in your maths lessons?
2) Do you like competing with other people in your maths lessons?
3) In your maths lessons who do you feel you are doing the work for?
4) Do you find it easy to answer questions in front of the class in maths?
5) Do you think that maths needs to be taught in a different way to other subjects?
6) Would you prefer to be set or not to be set for maths?
7) Do you think you get better results in maths homework or in maths exams or do you do as well in both?
8) Do you think you get better results in maths homework, maths lessons or maths exams?
9) What do you get out of your maths lessons?
10) Would you copy in maths?
11) When it comes down to doing your working out in maths are there differences between what is needed in everyday life and in school?
12) Can you see a clear connection between the work you do one year in maths and the work in other years?
13) Do you find any maths topics fun to do?
14) Do you ever guess the answer in maths?
15) What pleases you the most, getting the answer right or finding out a way of working out the problem?
16) Do you ever estimate a mathematical answer?
17) If maths lessons were optional would you choose to do them?
18) What were your reasons for choosing your options?
19) Could you imagine doing maths just for pleasure?
20) Now that many people have calculators do you think it is necessary to learn things like the four rules, multiplication tables, decimals, percentages and fractions or would it be enough just to know how to work them out on a calculator?
21) Are teachers failing in their jobs if they don’t make sure that you are working hard and really do your best to learn?
22) Does it surprise you if you can’t understand something fairly quickly in maths?
23) What method do you use to revise in maths?
24) Have you always used this method?
25) Do you use the same revision methods in other subjects?
26) Are you concerned about what your teacher thinks about how well you do in maths?
27) Are you concerned about what your friends think about how well you do in maths?
28) Are you concerned about what your parents think about how well you do in maths?
29) Are you yourself concerned about how well you do in maths?
30) Do you do better in other subjects than you do in maths?
31) Are your parents concerned about how well you do in maths?
32) Are you a fairly patient sort of person?
33) Do you ever do puzzles at home?
34) Someone said, "I like maths because it's a challenge. I find it different to other lessons because you have to do more working out yourself." What do you think about that remark?
35) Someone else said, "I think everyone can be good at maths." Do you agree with them? (If the answer was "No" then this would be followed by "Would you agree with them if they were talking about the maths you do in everyday life?")
36) Another person said, "I like maths because once you've learned the rules you can put them into practice." What do you think about that remark?
37) What sort of person do you think most enjoys learning maths?
38) What sort of person do you think gets most out of learning maths?
39) Would being able to do maths help you in getting a job?
40) Would having a qualification in maths help you in getting a job?
41) What do you get out of going to school?
42) Why do you think we have exams?
43) Do you think exams are a good idea?
44) Is continuous assessment a good idea?

7.2 Collection of data in the third interviews

7.2.1 Arranging the interviews

Very little groundwork was needed for the third interview
because the pupils were well used to my methods by now and needed little preparation. Furthermore, I had decided not to have a pilot study on this occasion. The questions were, presumably, relevant to the pupils since they arose from their own categories and I was sufficiently used to the routine of interviewing in the school to be confident that I would not encounter any great difficulties.

Transcription and analysis of the data from the second interviews and the videorecorded problem-solving sessions had taken a long time and it was some months after the latter before I finally had the questions prepared. However, I had kept in touch with the group during that time and a number of them showed interest in how my work was progressing. I used those occasions to remind the pupils that the third interview was in preparation and that this time it would consist of questions arising from the previous interview. In this way I tried to ensure that pupils were receptive to the idea of the third interviews when the time came and that there would be some degree of continuity.

I did not start the interviews as soon as I would have liked to because examinations for the group were only a few weeks away and I did not want to remove them from lessons at that time. Consequently the interviews did not take place until the end of June and the beginning of July of the pupils' third year at the school.

The week before the interviews began I visited the group and arranged times for individual interviews. As before, I made every effort to accommodate the pupils so that they missed lessons in which they were not very interested. On this occasion that was quite easy. They were taking up their options the following year and most had rather lost interest in those subjects which they were giving up.

There was one slightly worrying fact which arose at this time. On previous visits for this purpose pupils were eager
to arrange times with me although I have no doubt that for many of them the main attraction was not talking to me but missing a lesson. On this occasion a group of four boys held back and showed reluctance to arrange an interview. After a little persuasion they grudgingly agreed to take part but I was concerned for the quality of the interviews if they were so unenthusiastic. As it turned out I need not have worried. They all appeared to be perfectly at ease during their interviews and were very forthcoming. I concluded that now they were older they were more reluctant to appear enthusiastic in front of their peers but this must remain surmise. I deemed it diplomatic not to raise the subject.

When I made this visit I also organised an interview room that would be free throughout the time I needed it. This also was much less of a problem than previously. The pupils were, by now, seasoned members of Main School and there was less chance of them being intimidated by unknown areas of the buildings. A very comfortable office was vacant at this time because a member of staff had just left and had not yet been replaced and so I was confident of being able to conduct the interviews in pleasant surroundings and without interruptions. I described this room in chapter three (3.7.5).

7.2.2 Posing the questions

Each question was asked in the order shown in 7.1 above. If pupils gave simple yes or no answers I asked them why they had made that response or what the response meant. This was an obvious part of the approach but one to which I had given some thought in advance. From previous experience I knew that a few pupils were shy or reserved and would need gentle drawing out on their responses. I felt sure they would begin with limited responses and my assumptions were correct.
However, I was more concerned about the group who had shown apparent reluctance to be interviewed since there was the danger of the data being corrupted by unthought-out responses. Fortunately my approach mitigated this. Since the need to expand was apparent from the first question the pupils had early warning that unthinking responses would soon lead to difficulties. In the event I need not have worried. As I have just explained I encountered interest rather than antagonism.

Many of the questions asked specifically about maths lessons. One example is the first question, 'Do you like cooperating with other people in your maths lessons?' In all relevant cases where such questions occurred I followed it up by asking if this was the same for other subjects. This was to provide further insights at the individual level but I have not included these responses with the quantitative data. The number of responses would have almost doubled and would have made analysis exceedingly difficult.

Although the questions arose from categories produced by the pupils I sometimes developed the questions in ways which deviated from the language of the categories themselves. I shall now discuss these deviations, partly in order to ensure that I make clear all aspects of my work but also to explain some rather strangely worded questions. The explanations imply the categories which lie behind them.

Question seven, 'Do you think you get better results in your maths homework or your maths exams?' is, on the face of it, a quite stupid question. As soon as I had asked it, and before the pupil could respond, I explained my reasons for asking it. I pointed out that these were the two occasions when they did not have teacher or friends to turn to for help and I asked them to think of those occasions when they also had no one at home who could help. I used the question as an oblique way of finding out about self confidence when working
alone and also to see if the responses would indicate a belief that work during the year was as important as examinations.

Question eight was necessary because I knew that those in the bottom set are rarely given homework and this allowed for all pupils to be included.

I gave my explanation for question eleven before actually asking the question. The question was, 'When it comes down to doing your working out in maths are there differences between what is needed in everyday life and in school?' I posed the question in this form to find out if they thought that school maths was relevant to everyday life. I felt that some of the pupils would have had difficulty in answering had I posed that question in such a stark way so I used an oblique approach. I began by asking them to imagine that they were grown up with a home of their own to run and with such things as bills, tax returns and measuring up for carpets to cope with. I then posed the question within that framework. I stress that I was not expecting a response based on what they were likely to do in the future but on how they saw that at the present time.

Question fifteen, 'What pleases you the most, getting the answer right or finding out a way of working out the problem?' arose from categories that were to do, on the one hand, with the notion that you measure success in mathematics by the amount of work accomplished and, on the other hand, that what matters is understanding what the work is about. I decided that to ask direct questions here would be too value laden but I am afraid that posing the question in this way may not have obscured that. One of my first respondents said that she would like to say that finding out a way of working out the problem was what pleased her most but that she had to admit that since she found mathematics so difficult getting the answer right really came first. Given that response I
tried, in all later interviews, to ask subsidiary questions which would probe possible areas of bias. As it transpired the responses to this question did not discriminate between upper and lower sets and so it does not pose a problem of interpretation.

Question eighteen, 'What were your reasons for choosing your options?' was included in preparation for question nineteen, 'Could you imagine doing maths just for pleasure?' The pupils had just chosen their options and would be working at them in the following academic year. I was aiming to establish the difference between choosing for pleasure and choosing for perceived need. However, a year later I have seen their school reports and can, to some degree, compare their reasons for choosing the subjects with the degree of success which they have achieved in them. Not only does this provide useful background material on individual pupils but, equally importantly, the question turned out to be useful in a more direct way since analysis indicated the importance to this study of a number of beliefs or attitudes which were not mathematics specific.

Question twenty one, 'Are teachers failing in their jobs if they don't make sure that you are working hard and really doing your best to learn?' was one of the two questions which arose from those categories mentioned by all or most of the pupils in the second interviews. The category in this case was, 'Mathematics teachers should always be strict.' As it stood it was not clear if this category suggested the belief that the teacher should be strict as an enabling mechanism to provide an atmosphere conducive to work or if it suggested belief that pupils should be reactive to teachers' instructions to work rather than proactive in their own approach. The aim of this question was to probe those beliefs.

Question thirty two, 'Are you a fairly patient sort of
person?' was the second to arise in this way. It arose from the categories, 'When I find mathematics difficult to understand I keep trying/ give up' and was intended to provide some indication of whether or not the giving up was dependent on impatience or because of a belief that there is no point in continuing once a difficulty is encountered.

Questions thirty four, thirty five and thirty six, all of which refer to things which 'someone said', were the three questions which arose from the responses of only one pupil in the third interviews. They were all actually made by one person and I used the three of them together as a sort of sounding board against which to gain the reactions of other members of the group. The decision to include them was both arbitrary and subjective and I hesitated before doing so because I knew I would have difficulty in justifying them. Since it was also the case that only the first one discriminated between top and bottom sets and that only in a very minor way I think the decision to keep them in was not a good one. I am not suggesting that the failure of responses to discriminate indicates a poor choice of question in every case but only that in this case where I was already doubtful the choice was inappropriate.

7.2.3 The interviews

As on previous occasions the first few minutes of the interviews were spent talking to the pupils to remind them of the purpose of the interviews, to put them at their ease and to assure them of confidentiality. I also explained the nature of open ended questions and indicated that each initial question would be followed up by subsidiary questions to make sure I understood their responses. Since, as previously, I was tape recording the interviews, this time
was also used for setting up and testing the equipment with the pupils' help.

I then asked the questions in the way that I have already indicated and included the extra explanations or questions I discussed in the previous section.

In chapter five I discussed, analysed and drew conclusions about nine categories which had been mentioned by all or most of the pupils. In that chapter (5.5) I explained that six of these categories were not referred to by a few pupils and that I collected that data during the third interviews and incorporated it with the data for the second interviews. When I had finished asking the forty four main questions I asked these questions of those few pupils concerned. The same approach was taken as with the previous questions.

Finally I discussed with each pupil the profile I had built up of them as a result of the first two interviews and the videorecording of the problem-solving session.

Most of the interviews took approximately forty five minutes. Some were considerably longer. This was because the time taken to discuss pupil profiles varied considerably from one interview to the next since I allowed the pupil's apparent interest to be the deciding factor.

Because I was asking questions this time as opposed to eliciting the pupil's own ideas I asked the pupil, at the end of each interview, if the interview had been as enjoyable as previous ones. Unfortunately it had not, at first, occurred to me to get this on tape and so I have no specific data for all of them. My impressionistic data was that most of the pupils found this method enjoyable but less so than the previous ones.

The data from these interviews were used to provide both quantitative and qualitative information.
7.3 Analysis of the data

7.3.1 Transcription and first categorisation of responses

My first task was to transcribe each interview using a word processor. I then took printed copies, for each of the forty-four questions and the pupils' responses and cut them up into their individual components. Following this I collected together the material for each question so that now, instead of twenty-eight sets of all the answers of one pupil to each of forty-four questions, I had a collection of twenty-eight answers to each of forty-four separate questions.

Taking each of the forty-four questions in turn, I read through the responses and made piles of those which seemed to be similar. In each case I then decided on a label which seemed to categorise all those responses which I had collected together in one pile. Sometimes this led to the rejection of one or more members of the pile and occasionally it was necessary to start the sorting again and redefine the categories. It was a slow process.

As I completed the categorisation for the responses to each question so I used the word processor to record the question, the categories obtained from it, which pupils came into each category and any relevant remarks which the pupils had made. In this way, although I was no longer looking at the data for individual pupils I had a ready record of the responses for each one of them without the extraneous material such as my questions or irrelevant pupil comments.

For information at the quantitative level I now had a list of all the categories together with data about which pupils had provided them but, when it was required, I could still return to the original transcripts for personal qualitative data.

Rather than list all the categories here I have listed
each question in Appendix F1 and, in each case, I have followed the question with all of the categories of its responses. I have chosen this approach because not all the responses, or even all the questions, discriminate between pupils in the higher sets and those in the lower ones. Given that there are so very many responses, many of which are redundant except at the individual level, it seemed unsuitable to include them here where they would take up so much space. However, as I will explain in 7.3.3, the final categories were different to the original ones. It is the final categories which are listed in Appendix F1. The numbering of the questions also changes in Appendix F1 from the order in which they were originally asked. This is also explained in 7.3.3.

The next task was to attempt to group the categories. This proved to be difficult. I first made two attempts to group the response categories, then, directly, the questions and, finally, again the response categories, having removed the categories which did not discriminate between top and bottom sets. All this is indicated on the diagram below.

```
QUESTIONS ----> GROUPING 2
              ↓
RESPONSES ----> SECOND ----> SECOND CATEGORIES WHICH
                  ↓
FIRST CATEGORIES ----> GROUPING 1b
                        ↓
GROUPING 1a
```
7.3.2 First grouping

At this point I felt that I was making some progress but I still had to decide what to do with the categories I had developed. As they stood they were simply the categorisation of responses to each question. I now wanted to separate the categories from the questions which produced them and group them in some way that had an internal logic.

I was horrified by the daunting task which now faced me. I found that after all this work I had only managed to reduce the number of categories to two hundred and one. Colleagues had warned me in advance that one should be careful to keep data within manageable limits in order to avoid the difficult situation in which I now found myself. However, when using this approach to data collection, knowing what to reject is not a simple problem. With traditional approaches to research one's hypotheses determine which data will be collected. Over-collection of data suggests that the study was not well thought out. When the hypotheses arise from the data itself then this argument no longer holds good and unwieldy amounts of data are the price one pays.

I decided to begin by using my own judgements as to whether a category was likely to be one which would have a greater chance of being a factor in success or in failure in school mathematics. At the end of this sorting I had seventy seven categories which I judged could be involved with success, forty which I judged could be involved with failure and eighty four which I could only label as neutral.

To organise the data further I then divided the categories into ten groups. The method of grouping was similar to the way in which I later grouped the questions but I will describe it when I discuss that because, in fact, I discarded this grouping of the categories.

Each group had within it some categories which I had
considered to be connected with success, some which I had considered to be connected with failure and some which I had labelled as neutral. I kept together nine of the ten groupings as being to do with mathematics but the tenth grouping I put on one side as being general.

For convenience I now numbered each category. Numbers one to sixty six were in the first nine groupings which I had connected with success; sixty seven to one hundred and six were in the first nine groupings which I had connected with failure and numbers one hundred and seven to one hundred and sixty three were in the nine neutral groupings. Numbers one hundred and sixty four to two hundred and one were in the general group and made up of all three types.

Having reduced and organised the data in this numerical way I drew up a large grid which was numbered from one to two hundred and one in the columns and which had the pupils names in the rows. The pupils names were listed according to their mathematics sets in the order which I have used in the appendices except that there I have replaced names with numbers for the sake of anonymity.

I had hoped to see a pattern on the grid but all I could see was a large patchwork of ticks which told me nothing except that I had failed in my quest. I had to start my search again. However, I decided that the task of renumbering the categories was far too time consuming so I let them stay. Consequently the order of the numbers has no meaning.

7.3.3 Second categorisation

Some time had passed and I had, by now, become very familiar with the data. Furthermore, in my efforts at sorting and ordering I had begun to notice different possible combinations of categories and so I decided that, before
regrouping the categories, it would be useful to return to the original questions and their responses, and see if a better categorisation were possible.

The result was a considerable reduction from two hundred and one to one hundred and thirty five categories. There was a reduction into nine categories, of twenty one of the categories which I later found to discriminate in favour of the top sets. Similarly there was a reduction into twelve categories, of twenty five categories which I later found to discriminate in favour of the bottom sets. The largest reduction was in the neutral categories where sixty five categories were reduced to twenty four.

As I implied in section 3.1 above it is these reduced categories which are listed in Appendix F1 along with the questions and the responses from which they were derived. The labelling of the categories belongs to this second categorisation although the numbering is left over from the previous one. The changes are evident from the groupings of category numbers.

7.3.4 Second grouping

I now approached the problem from a different point of view. Instead of speculating as to which categories might go with success or failure I divided the categories according to how they discriminated, numerically, between the two top sets and the bottom three sets. There were, at this point, fourteen pupils in each of the two levels.

I considered together those categories where a) the members were predominantly from the top two sets (32 in all), b) where the members were predominantly from the bottom three sets (31 in all) and the rest, c) where the categories did not discriminate between the two levels. Eventually (see
sub-section 3.5) I discarded c). These neutral ones are listed for information in Appendix F1.

For the sake of clarity, for the rest of this study I shall refer to those categories which were subscribed to by more of either the top sets or the bottom sets as discriminating in favour of those sets.

Of course it was inevitable that any grid made up from either a) or b) would show a pattern. However, I decided that it was worth looking to see what information such a pattern could provide, particularly if the orderings were grouped in some logical way.

At this point, in order to produce individual grids for top sets categories, for bottom sets categories and for neutrals which were, at the same time, uniformly grouped, I decided to make a further change by grouping the questions directly, rather than the categories of responses.

I decided on five groupings. The first I labelled as 'Beliefs about the nature of mathematics and how to go about it'. This was by far the largest grouping as it contained nineteen of the forty four questions. The next group, which contained six questions, I labelled 'What Individual pupils get from learning mathematics and their beliefs about other people and maths'. The third group, 'Feelings about mathematics' also contained six questions and the fourth group, 'General beliefs not necessarily to do with mathematics' contained eight questions. As the label implies these were not mathematics specific. Finally, the fifth group which I labelled 'Possible sources, internal and external, of pressure to work hard (or not) in mathematics' contained only five questions. I am afraid the labels are far from short or pithy but the important point was that their meaning should be clear.

There is a case, at this stage, for relisting all forty four questions in their five groupings. However, following
the second categorisation, thirteen of the questions became irrelevant to the study because they did not discriminate in favour of either the top or the bottom sets.

This may need some explanation. The categories were labelled as discriminating in favour of top sets, discriminating in favour of bottom sets or merely neutral. The question to which any one category belonged was not involved at this point. Consequently it was perfectly possible for a question to contain only neutral categories. This did occur with thirteen of the questions.

It would, of course, have been feasible to remove those questions before making the five groupings but I decided that it would be interesting to discover if any of the groupings I had made were predominantly neutral.

The questions, including those which turned out to be neutral, remain together in Appendix F1 where the questions are listed and numbered according to the groupings made at this time. As with the numbering of the categories, when I later looked at the questions in a different grouping I let the numbering of the questions stay the same.

Now, of course, the grids for the new categories and groupings, which are shown in Appendix F2 Tables 1 to 7, did show a definite pattern which seemed to have meaning but, for a time, I was unable to have confidence in them. I could see only that because I had put together the categories which discriminated in favour of top sets or bottom sets then there would obviously be a pattern. It was self-fulfilling.

In retrospect I can now put together the sources of my confusion but at the time I could see no solution. I had, of course, lost my way when I began my first grouping of categories. Throughout the study, in collecting the data I had made determined efforts to discover what was important to the pupils and not what I thought important. The questions I had asked at the third interviews reflected that and,
clearly, some responses would reflect differences between top and bottom sets if there were beliefs and attitudes that were either helpful or inimical to success at school mathematics. And yet, when I made my first grouping of categories I attempted to decide for myself which categories would be associated with such success or failure rather than letting the data inform me. And, when I did begin to let the data inform me, I approached it as an organisational task and not as a means of enlightenment.

Had I thought this through at an earlier point I could have saved myself many hours of work and much anguish. And I no doubt deserved the trouble I had because I ignored one of the important suggestions made by those who are experienced in the Grounded Theory approach. That is that once one has developed one's categories and is at the level of concept formation one should discuss the work with colleagues in order to clarify and, perhaps, change one's approach.

Now that I knew which categories discriminated in favour of top sets and which in favour of bottom sets I decided to revisit my original theorising as to which of them would be likely to lead to success in school mathematics and which to failure. It was a very salutary experience. By chance there were forty two of the original categories which discriminated in favour of the top sets and forty two which discriminated in favour of the bottom sets. I had been correct for only eighteen of those for the top sets and twelve of those for the bottom sets. This highlights the importance of allowing the data to speak for itself and only later attempting to give it meaning.

A point of information may be needed here. I said that forty two categories discriminated in favour of the top sets and forty two in favour of the bottom sets. These were, as I remarked above, from my original categorisation. Following the second categorisation and reduction these forty two had
become thirty one for the top sets and thirty one for the bottom sets.

Below I list the questions in the five groupings into which I placed them and indicate those which turned out to have only neutral categories. Following that I list first those categories which discriminate in favour of the top two sets (i.e. the top fourteen pupils in the group) and then second those which discriminate in favour of the bottom three sets (the bottom fourteen pupils in the group).

A note of caution. With only fourteen pupils in the top two mathematics sets and another fourteen in the bottom three sets the notion of categories discriminating in favour of top set pupils or bottom set pupils is hardly pregnant with meaning. Very often this will indicate no more than that there are three more pupils, say, in the bottom sets who have subscribed to a particular category than there are pupils in the top two sets who have done so. And there are one or two cases (e.g. category 18) where only two pupils subscribed to a category which was sufficiently different to other categories to have to be labelled alone. Discrimination from such a category is based on very small numbers. Consequently the notion of discriminating categories can only be taken as indicative.

Appendix F2 Tables 1 to 7 indicate the categories in each of the five groups to which each individual pupil subscribed. As well as allowing for reference at the individual level, these tables make it possible to see the relative numbers of pupils subscribing to the categories which discriminate in favour of the top sets and to those which discriminate in favour of the bottom sets. They also indicate to which of the categories that I have labelled neutral, each pupil subscribed. The categories are numbered in the tables but cross checking with Appendix F1 will allow the reader to determine the label for any one of them. For each table, Part
Group 1:- Beliefs about the nature of mathematics and how to go about it

1) What method do you use to revise in maths?
2) Have you always used this method?
3) Do you use the same revision methods in other subjects?
4) Do you ever estimate a mathematical answer?
5) Would you copy in maths?
6) Do you ever guess the answer in maths?
7) What pleases you the most, getting the answer right or finding out a way of working out the problem? [NEUTRAL]
8) Now that many people have calculators do you think it is necessary to learn things like the four rules, multiplication tables, decimals, percentages and fractions or would it be enough just to know how to work them out on a calculator?
9) Can you see a clear connection between the work you do one year in maths and the work in other years? [NEUTRAL]
10) Does it surprise you if you can't understand something fairly quickly in maths?
11) In your maths lessons who do you feel you are doing the work for? [NEUTRAL]
12) Would you prefer to be set or not to be set for maths?
13) Do you think that maths needs to be taught in a different way to other subjects?
14) Someone said, "I like maths because its a challenge. I find it different to other lessons because you have to do more working out yourself." What do you think about that remark?
15) Someone else said, "I think everyone can be good at maths." Do you agree with them? (If the answer was "No" then this would be followed by "Would you agree with them if they
were talking about the maths you do in everyday life?")
16) Another person said, "I like maths because once you've
learned the rules you can put them into practice." What do
you think about that remark?
17) Would having a qualification in maths help you in getting
a job?
18) Would being able to do maths help you in getting a job?
19) When it comes down to doing your working out in maths are
there differences between what is needed in everyday life and
in school?

Group 2:- What individual pupils get from learning
mathematics and their beliefs about other people and
mathematics

20) Do you think you get better results in maths homework or
in maths exams or do you do as well in both?
21) Do you think you get better results in maths homework,
maths lessons or maths exams?
22) Do you do better in other subjects than you do in maths?

[NEUTRAL]
23) What sort of person do you think gets most out of
learning maths? [NEUTRAL]
24) What sort of person do you think most enjoys learning
maths?
25) What do you get out of your maths lessons? [NEUTRAL]

Group 3:- Feelings about mathematics

26) Do you find any maths topics fun to do? [NEUTRAL]
27) Could you imagine doing maths just for pleasure?

[NEUTRAL]
28) If maths lessons were optional would you choose to do them?
29) Do you like cooperating with other people in your maths lessons?
30) Do you like competing with other people in your maths lessons?
31) Do you find it easy to answer questions in front of the class in maths?

Group 4:- General beliefs not necessarily to do with mathematics

32) Why do you think we have exams?
33) Do you think exams are a good idea?
34) Is continuous assessment a good idea? [NEUTRAL]
35) Are teachers failing in their jobs if they don't make sure that you are working hard and really do your best to learn? [NEUTRAL]
36) What were your reasons for choosing your options?
37) What do you get out of going to school? [NEUTRAL]
38) Do you ever do puzzles at home?
39) Are you a fairly patient sort of person?

Group 5:- Possible sources, internal and external, of pressure to work hard (or not to) in mathematics

40) Are your parents concerned about how well you do in maths?
41) Are you concerned about what your friends think about how well you do in maths?
42) Are you concerned about what your parents think about how well you do in maths? [NEUTRAL]
43) Are you concerned about what your teacher thinks about how well you do in maths?
44) Are you yourself concerned about how well you do in maths? [NEUTRAL]

**Categories which discriminate in favour of higher sets**

57) For maths revision I learn how to do the topic and work through some examples.
49) My revision methods have changed. (Method demonstrates that the change is for the better.)
76) My revision methods are different for maths to other subjects. In other subjects I don’t do working out.
16) I estimate in maths. (Examples given.)
50) I would copy but only to work through and gain understanding.
122) I would make a calculated guess in maths.
65) You need to learn the method as well as how to do it on the calculator because it's important to understand.
2) I'm not surprised if I don't understand quickly in maths. It always takes time.
28, 29, 121) I prefer to be set so as not to be held back.
162, 163) Maths needs to be taught more thoroughly and with more explanation than other subjects.
155) Maths is a challenge and there is more working out.
6, 108) Everyone can be good at maths if they work hard.
159) Maths is rule based.
45) A maths qualification would help me. I need one for the job I want to do.
42) Being able to do maths would help me. I need it for the job I want to do.
27) I would use school-taught methods to do everyday maths.
92, 93, 144) I get better results in homework than in exams because there is less pressure.
47) I achieve as well in class, at homework or in exams.
96) The person who most enjoys maths is the one who is good at it.
33, 34) I would still do maths if it was optional because I need it and I quite like it as well.
1, 26) I like to cooperate because you can help each other.
4) I don't like to compete because I prefer to do my own thing.
187) We have exams to see how much we have learned during the year.
194, 197) I don't approve of exams. Continuous assessment is better.
200) I chose my options from a mixture of choice and need.
188, 190) I do crossword puzzles. (Some also do other types of puzzles.)
181) I'm not very patient but I don't give up easily in maths. I get frustrated and stop but then I come back to it. I am the same with other subjects.
23, 114) My parents are concerned about how well I do in maths because it's an important subject.
22) My parents are concerned about how well I do in all subjects.
129) I'm not concerned about what my friends think about how well I'm doing in maths. It's what I know myself that matters.
13) I'm concerned about what my teacher thinks of my progress in maths because I try to demonstrate that I am making progress.
125) I would not copy in maths.
Categories which discriminate in favour of lower sets

56) For maths revision I read through and do some examples.
83) I've always used the same method for revision.
   (Indicating a method likely to be unhelpful.)
79) I revise for other subjects but not for maths.
124) I estimate in maths. But couldn't say when. (Suggesting a feeling that it's a good thing to do but not knowing how to use it.)
89) I would copy to get out of trouble or just to keep up with others.
97) I would guess the answer in maths. (Pure guess)
118) I'm not surprised if I don't understand quickly in maths. It's always difficult for me.
110) I prefer to be set so that I won't fall behind or I won't copy.
60, 61) Maths doesn't need to be taught differently to other subjects. (Two added that pupils had to work harder.)
103) Maths is more working out but I don't like the challenge of it.
119, 120) Not everybody can be good at maths but they can be good at everyday maths. (Two disagreed with the latter)
59, 158) Maths is not rule based.
151) I don't know if a maths qualification would help me to get a job.
43) Being able to do maths would help me because it is needed for any job.
154) I'd do maths at home in a different way to how it is taught at school.
142) I don't know if I do as well in homework as exams.
91) I get better results at home. There is pressure or distraction in class and exams.
148, 149) I would do maths if it was optional although I don't like it. Reasons:- I need it for the job I want to do or it
is important for any job.

66, 67) I sometimes don't like to cooperate with others. One said "Not unless I know I can trust them." The other one said, "Because I probably wouldn't work."

17, 126) I like to cooperate with others for what I can get out of it.

68) I don't like to compete with others because I'm no good at maths.

184, 185, 186) We have exams for one of following reasons: - So we can be put into the proper set or as practise for external exams.

183, 185) I approve of exams. (As opposed to continuous assessment)

187) I chose my options only for liking.

201) I chose my options only because I need them for a job.

189) I don't do any sort of puzzles.

188, 182) I'm not patient so I just give up if I can't do it.

87, 88) My parents are not really concerned about how well I do in maths.

129a) I'm not concerned about what my friends think about how well I'm doing in maths. I can only do my best.

18) I'm not concerned about what my friends think about how well I'm doing in maths. They don't want me to work. I might want to.

75) I'm not concerned about what my teacher thinks about how well I'm doing in maths. I can only do my best.

115, 117) I only find it easy to answer questions in front of the class if I'm sure I won't be laughed at.

7.3.5 Third grouping

The first grouping of categories was done using the categories themselves but the second grouping was done on the
basis of how the questions seemed, to me, to cluster. While the second approach is useful I, nevertheless, felt that grouping from the way the categories appear to cluster could be equally informative. I considered returning to my first grouping of categories but decided against it when I reflected on how wrong I had been in my original choices and how many of the categories had turned out to be neutral. Instead, as I indicated in sub-section 3.4, I decided to regroup the two sets of thirty two and thirty one categories which still remained meaningful for the study.

I did this by taking each group, writing the labels for the thirty one or thirty two categories on slips of paper and sorting them into different groupings until I felt I had those which clustered together most naturally.

Eventually I had four groups which discriminated in favour of the top sets and six which discriminated in favour of the bottom sets. Unfortunately this left ungrouped sixteen categories with eight coming from each type of discriminatory set. These are listed below and the actual pupil responses are given in Appendix F3 Tables 1 to 3.

In spite of the ungrouped categories I have decided to let the groupings stand because they do seem to have meaning and they do discriminate. It may be that some categories do not group naturally.

Naturally some categories might have equally fitted into another group. For instance category 181, 'I'm not very patient but I don't give up easily in maths. I get frustrated and stop but then I come back to it.' could also be placed in the first group for the higher sets on the basis that it suggests a belief that maths can be a frustrating subject for anyone so you just have to keep trying. For the same reason, but from the opposite point of view, category 188 and 182, 'I'm not patient so I just give up if I can't do it.' could be placed in the first group for the lower sets.

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In order that readers might judge for themselves whether the second or the third grouping was more useful I have
included Appendix F3 Tables 1 and 2 which indicate which pupils subscribed to which categories in the different
groups. It should be remembered that on this occasion those categories which were neutral are not included. Once again,
Part X of a table refers to the top sets and part Y to the bottom sets.

Groupings of response categories which discriminate in favour of higher sets

Group 1:– Awareness of how to go about things and a willingness to do so

122) I would make a calculated guess in maths.
50) I would copy but only to work through and gain understanding.
16) I estimate in maths. (Examples given.)
57) For maths revision I learn how to do the topic and work through some examples.
49) My revision methods have changed. (Method demonstrates that the change is for the better.)
76) My revision methods are different for maths to other subjects. In other subjects I don’t do working out. (Merely backs up d).)

Group 2:– Intrinsic push to do well in maths

28,29,121) I prefer to be set so as not to be held back.
45) A maths qualification would help me. I need one for the job I want to do.
42) Being able to do maths would help me. I need it for the job I want to do.
33,34) I would still do maths if it was optional because I need it and I quite like it as well.
181) I'm not very patient but I don't give up easily in maths. I get frustrated and stop but then I come back to it. I am the same with other subjects.
23,114) My parents are concerned about how well I do in maths because it's an important subject.
22) My parents are concerned about how well I do in all subjects.

Group 3: Confidence in one's own ability

2) I'm not surprised if I don't understand quickly in maths. It always takes time.
1,28) I like to cooperate because you can help each other.
4) I don't like to compete because I prefer to do my own thing.
13) I'm concerned about what my teacher thinks of my progress in maths because I try to demonstrate that I am making progress.
129) I'm not concerned about what my friends think about how well I'm doing in maths. It's what I know myself that matters.

Group 4: Belief that work through the year is as important as exams

187) We have exams to see how much we have learned during the year.
194,197) I don't approve of exams. Continuous assessment is better.
Categories which did not fit into any group

6,108) Everyone can be good at maths if they work hard.
47) I achieve as well in class, at homework or in exams.
27) I would use school-taught methods to do everyday maths.
65) You need to learn the method as well as how to do it on
the calculator because it's important to understand.
159) Maths is rule based.
162,163) Maths needs to be taught more thoroughly and with
more explanation than other subjects.
200) I chose my options from a mixture of choice and need.
188,190) I do crossword puzzles. And some who also do other
types of puzzles.
155) Maths is a challenge and there is more working out.
125) I would not copy in maths.
98) The person who most enjoys maths is the one who is good
at it.
92,93,144) I get better results in homework than in exams
because there is less pressure.

Groupings of response categories which discriminate in favour
of lower sets

Group 1:- Lack of understanding about how to go about things
or an unwillingness to make the effort

56) For maths revision I read through and do some examples.
83) I've always used the same method for revision.
   (Indicating a method likely to be unhelpful.)
124) I estimate in maths. But couldn't say when. (Suggesting
   a feeling that it's a good thing to do but not knowing how to
   use it.)
79) I revise for other subjects but not for maths.
Group 2:-- Lack of belief in own ability

118) I'm not surprised if I don't understand quickly in maths. It's always difficult for me.
110) I prefer to be set so that I won't fall behind or I won't copy.
103) Maths is more working out but I don't like the challenge of it.
17,126) I like to cooperate with others for what I can get out of it.
68) I don't like to compete with others because I'm no good at maths.
115,117) I only find it easy to answer questions in front of the class in maths if I am sure I won't be laughed at.

Group 3:-- Lack of intrinsic push to do well in maths

151) I don't know if a maths qualification would help me to get a job.
168,182) I'm not patient so I just give up if I can't do it.
87,88) My parents are not really concerned about how well I do in maths.
75) I'm not concerned about what my teacher thinks about how well I'm doing in maths. I can only do my best.
129b) I'm not concerned about what my friends think about how well I'm doing in maths. I can only do my best.

Group 4:-- Extrinsic reasons for doing maths

43) Being able to do maths would help me because it is needed for any job.
148,149) I would do maths if it was optional although I don't like it. Reasons:-- I need it for the job I want to do or it is important for any job.
184,185,186) We have exams for one of following reasons:- So we can be put into the proper set or as practise for external exams.

Group 5:- Having priorities or beliefs which clash with working at maths

89) I would copy to get out of trouble or just to keep up with others.
97) I would guess the answer in maths.
86,87) I sometimes don't like to cooperate with others. One said "Not unless I know I can trust them." The other one said, "Because I probably wouldn't work."

Group 6:- The school maths approach is not for everyday life

118,120) Not everybody can be good at maths but they can be good at everyday maths. (Two disagreed with the latter.)
154) I'd do maths at home in a different way to how it is taught at school.

Categories which did not fit into any group

59,156) Maths is not rule based.
91) I get better results at home. There is pressure or distraction in class and exams.
193,195) I approve of exams. (As opposed to continuous assessment.)
60,61) Maths doesn't need to be taught differently to other subjects. (Two said that pupils had to work harder.)
142) I don't know if I do as well in homework as exams.
18) I'm not concerned about what my friends think about how well I'm doing in maths. They don't want me to work. I might want to.
189) I don't do any sort of puzzles.
167) I chose my options only for liking.
201) I chose my options only because I need them for a job.

7.4 Conclusions

Before discussing the results I should like to say something about the categories listed either in 7.3 above or in Appendix F1. Taken out of context many of these appear to be rather trivial. This highlights the fact that this sort of data tends to be much more informative at the individual level than when it is abstracted for quantitative purposes. The data will be used at the individual level in chapter eight when I present three case studies of individual pupils.

The information presented here has been totally at the quantitative level. The main purpose of this study has been to establish whether or not there are attitudes and beliefs which pupils of secondary school age bring with them to their mathematics lessons which influence their success, or lack of it, in the subject as it is learned in school and, to this end, I have presented the data at a quantitative level in order to demonstrate the differences between the top and bottom sets in this group of pupils.

I believe that I have established that differences do exist. The data displayed in both Appendix F2 and Appendix F3 shows the extent to which, in this particular group, pupils in top and bottom sets vary from each other. The difference is far from total of course. And the data suggests that it is not specific attitudes or beliefs that help in success or failure but rather some clustering which is specific to each individual. Of course whether or not these attitudes and beliefs are what initially led to success or failure or if success or failure fostered them is something which can,
probably, only be discovered at the individual level.

My last comment leads to a rather important point. I am not putting forward either the beliefs or attitudes reported in this work as being permanent parts of the belief systems or personalities of the pupils concerned. That approach would not be in keeping with the philosophical beliefs which inform my approach. As situations change or develop so may the attitudes and beliefs of individual pupils change. Indeed, they may already have changed, although, in fact, the remarkable stability of many of their attitudes and beliefs has rather surprised me. Perhaps that says more about the unchanging nature of their lessons than the pupils themselves.

Another rather important point is that, in this chapter, the way in which I discuss the data leads only to information about what is the case and not why it is. In other words I demonstrate only that pupils suscribed to the categories and say nothing about the meaning behind individual subscriptions. I did, on occasion, use background knowledge from previous interviews and the problem-solving sessions to illuminate some remarks which seemed ambiguous in retrospect but in general I have not, at this stage, attempted to interpret but only to provide information.

I labour this point because there is the danger of putting the pupil's responses into a straightjacket once they are categorised. The categories are useful for showing trends or developing theories but are better left as responses in context at the individual level.

Basically I am arguing that what I have developed is a rather blunt way of showing up the differences between pupils who are successful in school mathematics and those who are not. In order to refine the findings I am going now to look at individual pupils across all the data I have for them from the first, second and third interviews and the videorecorded
problem-solving sessions. As I have already indicated these case studies will be given in chapter eight.

In this chapter I have attempted three different types of groupings. In the first grouping, I attempted to collect together the categories without first finding out which discriminated in favour of the top sets, which discriminated in favour of the bottom sets and which were neutral. This approach, which in retrospect was obviously a foolish one, did not produce any results.

The second grouping was of the questions rather than the categories. The basis for this grouping I discussed in 7.3.4 above where I also listed the questions in accordance with their groups. I provide more detail in Appendix F1 where the questions are again listed within their groups but where the categories are also listed, each one being below the question from which it arose.

The third grouping, which I discussed in 7.3.5 above, was of the categories which discriminated in favour of the top sets and those which discriminated in favour of the bottom sets. I listed the categories, in accordance with their grouping, in 7.3.5.

The major conclusion that I come to is that my data showed that there are differences between top and bottom sets which are not simply differences of mathematical ability but rather are differences of beliefs and attitudes.

However, it is also clear from Appendices F2 and F3 that although there is a general difference between top and bottom sets, when one looks at individual cases within either the top or the bottom sets there are enormous differences between individuals and that at this individual level it is a specific clustering of attitudes and beliefs that is important.
Chapter 8

CASE STUDIES

Introduction

In this chapter I shall discuss three of the pupils in detail. Their names have been changed for the sake of anonymity.

I decided to look at one pupil who is failing at mathematics, one who is succeeding and one who is in the middle. That was the easy part. The difficulty arose when it came to deciding which three to choose. I have, over a three year period, become very interested in all twenty eight of the pupils in the group and, ideally, I would like to have written about each one in turn. As this was not possible I had to develop some criteria for choosing one pupil rather than another. I will discuss my criteria before turning to the three pupils I eventually chose.

One criterion I considered was representativeness. I soon dismissed this because, apart from failing, succeeding or being in the middle none of the pupils can be said to be in any way representative of others. As I have already indicated in chapter seven, it appears to be constellations of categories which lead to success or failure in school mathematics and those constellations are specific to the individual.

Another criterion which I considered was the extent to which a pupil was willing and able to clearly convey their ideas. At first I rejected this because I was concerned that by leaving out pupils who appeared to have less facility with concepts and words, I would present a distorted picture of the group. Eventually I decided that it was a valid criterion to use because, since I had chosen to select only three
pupils to discuss, it seemed sensible to choose three who had plenty to say and could say it well. In fact, only four pupils would have been eliminated on this basis; two from the top sets and two from the bottom sets. So it became a matter of fine discrimination. However, the reader should bear in mind that I have done this.

At the end of my deliberations I settled on only one other criterion and that was that I should find it relatively easy to use the background data to account for a pupil's mathematical position in the group. This is another somewhat problematic criterion because it could give a distorted impression concerning the success of my findings. I justify it on the same grounds I used above and I give the reader the same caution. However, I would add that when I considered the matter I found that the same four pupils would have been eliminated on this criterion. The reason being, of course, that their reticence led to a limited amount of background knowledge which in turn made it difficult for me to interpret their responses with a high degree of confidence. I imagine that other researchers must encounter the same problem.

8.1 David

David is a remarkable raconteur. Most of the group were more than willing to talk to me about themselves and their ideas, although one or two had to be gently encouraged, but with David my problem was to get a word in edgeways in order to ask a question or clarify a point. He holds clear views on many things and by any of my criteria he would have been a good candidate for selection for discussion.

He is a boy who has failed to make any progress in mathematics although, in the videorecorded problem solving sessions, he proved to be very quick and able. But an
important reason for choosing him is that the data from his interviews both makes it possible for me to chart his failure clearly and suggests the reasons behind it.

Because of this I have decided to discuss David in some detail and, in particular, to discuss his first interview at some length. Although it was not specifically concerned with mathematics I believe it provides material which is extremely relevant to his lack of progress in the subject.

David was totally involved in the first interview and this remained so whenever I talked to him. He was willing to initiate conversation rather than just wait for my questions and he was frequently ahead of me in working out what the next triad of elements should be. Unlike most of the other pupils, he did not always wait for my elicitation routine but would, frequently, be considering constructs before I had even sorted myself out. I found myself wondering if this type of behaviour might not, at times, bring him into conflict with authority in the hierarchical world of school.

From the start ideas came tumbling from David's lips as though he had been saving them up as a present for someone who would take the time to listen to him. And, in a sense, this was probably true because, although when he was initiating a piece of conversation he would put together his ideas very clearly, at times his eagerness to communicate them made it difficult to grasp his meaning.

Furthermore, in response to a question, he tended to answer first and think later. I grew to believe that David did this from an unconscious belief that responses ought to be immediate although it is equally possible that he discovered that if they weren't immediate other people quickly lost interest. Whatever the case it was another example of behaviour which could be labelled, however vaguely, as inappropriate.

A typical example of this type of behaviour occurred when
I asked him to think of ways in which any two of the elements English, Cookery and Religious Education were alike. His immediate response was:

"English and R.E. because they've both got something to do with Jesus and the Bible".

This was a rather bewildering response but it soon became clear that he was thinking aloud as he developed the construct. He went on to say:

"We have to do writing in R.E. and punctuation and that. And we have to write in English in R.E. because if we wrote in French it would be a little bit weird. But in cookery we don't do a lot of writing".

The construct he developed was concerned with writing as opposed to practical work and had nothing to do with either Jesus or the Bible.

I am not suggesting that David responds in this way invariably, but I would suggest that he does it sufficiently often for it to have the effect of making it less likely that he, and his ideas, will be taken seriously, particularly in the world of school where many comments from pupils are made in response to teachers' questions. His initial responses may frequently appear to be irrelevant thus leading to disengagement by the questioner before the real response is given.

By the end of the first interview I was concerned about this because, although he was a delight to talk to under those particular circumstances and a gift to any interviewer, I was well aware that in the context of the classroom he
could easily be labelled as something of a problem and treated accordingly.

My concern was heightened by the fact that David appeared not to have developed the habit of answering questions in the abstract. All his responses were in the particular and given in great detail and, although this too was very useful to me, experience suggested that such responses are less valued in the context of school than are those which are both more structured and more abstract.

I hasten to add that this is an observation and not a judgement. I make no inferences as to why this is the case other than to suggest that, where there are large groups of pupils being taught by one teacher, lack of time favours those pupils who give responses which convey their message briefly and clearly.

By the time I returned for the second interviews the following year it was clear that David and the school were definitely in conflict and that one of the casualties was his progress in mathematics. Nor was he doing any better in most other academic subjects because he was simply no longer trying. And yet, in the first interview, he had shown himself to be very eager to learn.

However, his interests were not entirely in line with the way school subjects tend to be taught. One or two examples should make this clear. One of the constructs he produced was 'Subjects that make me wonder how people created them/Subjects I do without thinking about other people.' There were only two subjects, French and English, that did not make him wonder. On the subject of art his comments ranged from the early cave painters to Van Gogh and when he came to music he said:

"That makes me think one of the most because I wonder how people made the instruments and"
Concerning mathematics he said:

"I like maths".

When I asked him why, he replied:

"Its just some of the sums and things. They're quite funny when you find out how they work it out. And you're thinking, in the back of your mind, I wonder how they did that or I wonder who thought of them first of all".

From many things that David said in all three interviews it seems clear that his mind would often wander off onto such topics which, while fascinating in themselves, are not really in line with the school syllabus. As I hope to demonstrate, it was also clear that, during this time, nothing occurred which made him believe that he should change his ways and pay attention to what the school believed he should be learning rather than that which he himself found interesting.

I deliberately chose the words 'change his ways' rather than writing about him developing self control because there is evidence that when David cares to he can show self control. That is certainly the case as far as Army Cadets is concerned. He works very hard there because he wants to join the army and knows that that could help him. From his teachers I have learned that he believes it is more important to spend time preparing his uniform than doing homework even if it results in a detention. And he gave me a graphic description of the way he will just take his punishment, rather than argue about it being unfair, at cadets. From many
sources, including David, I know that in school he would not show such restraint.

However, I think David himself believes that paying attention is a matter of self control, at least to a certain extent. When, in the third interview, I asked him if everyone can be good at mathematics I expected him to say yes because, in the second interview, he had made it plain that he thought learning depended on the effort one makes and not on inborn ability. Initially then, I was surprised when he said that not everyone can be, but his explanation clarified things. He said:

"No. I can't. You can't tune your brain and some people are inclined to other things, you know".

I asked him why he was not tuned in and others were. He replied:

"You've got to have a blank mind when you do it, you know. When you get down to maths you think of maths alone and I can't do that because I'm usually thinking of, 'Oh, where am I going on Friday night?' and, 'Oh, what's the film on tomorrow night?' and, 'I'm going to get a video out' and, 'I'm going to buy a track suit in two weeks time' and, 'I'm going to wear trainers on Friday the 28th. of June' and anything like that, you know. Sometimes my mind can concentrate but I never feel fully involved".

I asked if that meant he thought some people had the ability to empty their minds and he responded:
"Yes, its been trained hasn’t it?"

I asked how the training is done and he said:

"They do it themselves don’t they? They discipline themselves".

On the other hand he was also aware of priorities. After his last remark I asked him if everyone can discipline themselves and he replied:

"Yeah, but you have to be.. err, say if I was marvellous at English. I wouldn’t want to discipline myself to maths because I’m already good at English and I’d think of that subject alone, wouldn’t I?"

There were two other factors which I noted during the first interview which I believe were influential in David’s development. The first was his self-reliance which, I believe, already shows through in much of what I have written. A further example of his self-reliance comes from two constructs which he developed concerning his ability. The first concerned subjects which he believed himself to be either good or poor at and the second concerned the subjects that his teachers believed him to be good or poor at as shown by his recent report. The differences were not great but they did exist. I am drawing attention to this to indicate that David is not willing simply to accept the measure of other people.

The second, which I am sure interacts with his self-reliance, comes from another construct which he developed. This was, ‘Subjects which are important for everyday life/Subjects you don’t need out of school.’ Mathematics, English,
Cookery and Geography were the only ones he thought important but it is notable that of Art he said, in a very whistful tone:

"Art. No, we don't need that. Its a five unfortunately".

He made a similar response about music and I gained the impression that he already had a very narrow view of usefulness.

What I am suggesting is that already, in the first year of the secondary school and probably sooner, David not only behaved in a number of ways which would probably not endear him to his teachers and could lead to conflict but, also, held beliefs which, together, could militate against success in school mathematics. Firstly, he believed in self-reliance and was, therefore, unlikely to work simply to please anyone else or because anyone else told him he should. Secondly, he had begun to develop a restricted view about which elements of the school curriculum would be useful out of school. As yet, this did not appear to be influential but certainly by the second interview he had come to believe that only basic arithmetic was of any importance to him and that there was, therefore, no good reason why he should put himself out to learn any other topics unless he found them interesting or easy. Together with most of the other pupils in the group, he mostly did not find them easy but, unlike many of them, he lacked other motives for making an effort to learn.

An example of this from the second interview arose when I was asking him why he found some topics extremely difficult. He said:

"It's just overall. I can't do anything. My mind doesn't try anything I don't think will
be useful. If I try and do those graphs, I
do try but then my mind doesn't take it all
in".

And during the third interview he told me that he liked
basic arithmetic and money problems because:

"...they are dealing with everyday life".

Explaining topics that he did not like he said:

"Why don't I like it? Because sometimes I sit
down and think, 'why should I be doing this?
Its not going to be useful in my life'. But
I've got to do it. Its all maths isn't it?"

Nevertheless, as the last part of that comment suggests,
it seems likely that his belief about usefulness is only one
of a constellation of influences on his behaviour although it
was already clear by the second interview that David's life
out of school and his part time job were more important to
him than is perhaps the case with many boys of thirteen.

By the following year and the third interview it was even
more pronounced. I had asked him what he got out of coming to
school and besides talking about having a good time with his
mates he said:

"Knowing I've learned something today that I
might forget tomorrow but I did learn it. You
know, I might have forgotten it but at least
I went through that day and learned it".

But then he added:
"I don't really think of school as the most important thing though. I used to 'cos I never used to have anything planned. Now I wait till Saturdays and Sundays to go to work and, you see, it revolves around that because I'm earning money. And it all boils down to money".

In spite of this, responses from his third interview suggest that if David had found the topics easy to understand he may well have been willing to do them out of interest. He said, on that occasion, that he had chosen his options purely for pleasure because he needed only English and mathematics to enable him to join the army. He added:

"I may as well have lessons that I like before I go into the army. Not all flat out and do boring ones".

Later he said:

"Nobody really likes school because they're really put through it aren't they?"

I asked him what he meant and he replied:

"Well, you have to go. Nobody really loves school. You have to go through it. You may as well make it enjoyable as you go through it".

However, for David to have found the topics easy to understand he would have had to concentrate and I have already indicated that he is not prepared to discipline himself to that. And there were other factors at work which
helped to make concentration unlikely. The first of these was that he is one of those pupils, discussed in chapter five (5.5), who find it difficult to work when there is any noise or messing about. He can handle it, to a certain extent, if he is seated alone away from those who are not working but, since his inclination is to join in rather than try to ignore the distraction, he had by that time become most friendly with those who would sometimes avoid work. When he was with them rather than seated alone there was little likelihood of his staying aloof. He explained it to me thus:

"Well, it's a bit hard when you've got all your mates around you. They say I don't work very hard in my lessons. Well, sometimes I try. And sometimes, when you're trying in your lessons for once, they do take the micky out of you. So, you try, and there's your mate tapping you on the shoulder and pulling round on your chair. And then your mind just loses interest. I don't think they do it on purpose. It's just that they're always used to me not working that hard".

That in itself is hardly remarkable. Teachers up and down the land could provide many such examples but David's next remark points up the fact that pupils vary in their ability to handle work and conversation at the same time and this is something which tends to be forgotten. I had made a comment about his friends not working and he replied:

"Well, they are a bit. Like Peter. He's lucky because he can do that and still have enough interest to keep him going. So he can talk and work at the same time. I've got to
concentrate either on them or on the work”.

So, for David, the happy medium of work mixed with conversation does not exist. It is all or nothing.

On occasion, David's emotional state also impedes concentration. Strictly speaking emotions are not relevant to a study about attitudes and beliefs but the dividing line can be a problem. McLeod (1987) writes of the difficulties found in specifying what is what in the affective domain. David described what seemed to me to be 'periods of feeling depressed' and I will return to these in a moment although I will not comment on the events concerned since they are not relevant to this study and are of a personal nature.

The point I would like to make first is that, providing this is not a clinical state, it could be argued that while such emotions may be involuntary the decision whether or not to allow them to affect one’s activities may be said to arise from one’s belief system, however acquired.

Life has not been entirely kind to David. I am not sure that he sees it that way and he certainly made no complaints to me but that is the message that comes from many of the events and occasions he described to me. How this sometimes makes him feel he explained when we were discussing his ability in mathematics. He said:

"I'd like to think I'm, you know, pretty good at everything but I can't level it out because some days I'll try and some days I won't. If I could get over that... I don't know why. I just... you know, some days you come in, 'oh I can't try today'. I feel I can't try. My brain's not working properly, you know".
I asked if he knew what caused it and he replied:

"Sometimes you just feel so dull and you could sit in the chair and look at a light switch for ten minutes without anything happening".

I asked if that was because he was tired and he answered:

"It's not tired. It's either fed up or you just can't be bothered to work. You just switch off. Your brain switches off but you're still looking at the light switch".

This is hardly the type of situation that leads to the steady attention needed for success in school mathematics where much depends on carefully following all that the teacher says.

Much of what I have discussed here arises from David's general attitudes and general belief system rather than from anything specifically to do with mathematics. I make no apologies for this because the rather obvious findings from my study indicate that while the two systems can be separated out their effects cannot. Thus it is that one of the pupils absolutely loathes mathematics but is in top set because of her belief that she ought to be good at all subjects and because, as her responses to my questions in the third interview show, her beliefs about how one should approach the study of mathematics are effective. At the same time, there are other pupils whose attitude towards mathematics are quite positive but who fail to succeed because their beliefs are less useful. In David's case the general beliefs are far more of a hindrance to success than are his specifically mathematical ones; this is one of the reasons that I chose to
Before turning to the responses David gave to my questions in the third interview I will discuss one more aspect of his general belief system which, I believe, greatly influences his progress in mathematics. This concerns his belief that it is sensible to do anything that will keep life trouble free. It is a belief which inevitably comes into conflict with other beliefs, such as the one that he should be self-reliant and which, if he does not modify it, is likely to lead to problems if he does join the army.

There are a number of examples, referring to events from early childhood onwards, which allow one useful insights into why David might have come to believe that keeping out of trouble is sensible but I will not detail them here. What is important is that it is a belief which carries with it the corollary that when it holds sway short term interest is all that matters. This belief is a very potent one for David and it reaches into all aspects of his life. He gave a graphic description of it working when he said:

"Say I've just broken a window. I've got to make up an excuse really quick you know. And all I can think of are two excuses, 'I'm sorry, I've just kicked a football in your window by accident', or 'I was nearly hit by a car and I was driven to throwing my ball through your window 'cos the car propelled me to do that'. So I think quickly off hand. I think, 'oh, I'll do the one about the car so I won't have to pay for the window'".

All this is a long way from mathematics but I feel the same general belief is at work, influencing mathematical beliefs, in approaches to work such as this example which
David provided in his second interview. I had asked him what he found difficult about positive and negative numbers and he replied:

"My mind jumbles up and thinks what they would be normally. Normal as in up. But with the minus sign and the plus sign and all those down the middle I get a bit confused".

I asked him what he would do to help him work them out and he said:

"Well, I wouldn't think of those minus signs at the top. It's as though I forget that I saw them. My brain gets confused and I ignore them 'cos then I know it'll be easier. My brains going, 'what does that mean? Where were we? Oh, I'm just going to leave it.', and then I just ignore the other minus sign and say eight minus five equals".

McLeod (1985) discussing the concept of automaticity in mathematical work suggests that some pupils may believe that frustration is a signal to get help rather than a normal part of problem solving. In David's case it seemed to be a signal to compromise, as above, or to give up. In response to my question, again in the second interview, about how he felt when the work was going wrong he said:

"It just makes me feel that I don't want to do it no more. If you get something wrong you're 'agh'. A rant and a rage and then think of something else. Its just anger that you thought you had your mind just going,"
'yeah, that's right. That's a good answer. That's right.' Then you see it isn't. So, 'ugh, I'm not doing these again.' It's a case of if I can't do it I don't like it, sort of thing".

I refer to McLeod's argument here because I think the situation can be rather more complicated. I think he is probably correct and I feel sure that, in many cases, that belief will be specifically related to mathematics. However, in other cases, such as David's, I would argue that it will have, informing it, a more general belief such as the one I have discussed.

And where this particular general belief touches David's beliefs about mathematics brings me at last to his responses to my questions during the third interview. He is pupil number eight in the appendices (not the eighth pupil down). I will discuss one or two of his responses in order to demonstrate how I see his general beliefs influencing particular mathematical beliefs but I will leave the reader to interpret the rest in the light of his or her interpretation of my description of David.

But first some general points about David's responses. For the first group, which I labelled 'Beliefs about the nature of mathematics and how to go about it', he subscribed to more categories which discriminated in favour of the top sets and fewer of those which discriminated in favour of the bottom sets than did most of the other pupils in the bottom sets, suggesting that it is not in this area in which problems created by his beliefs are most pronounced. However, in the other four groups he subscribed, in total, to only one category which discriminated in favour of the top sets. Furthermore, he subscribed to four out of the possible five categories which discriminated in favour of the bottom sets.
in the fourth group, 'General beliefs not necessarily to do with mathematics', and to all three categories which discriminated in favour of the bottom sets in the fifth group, 'Possible sources, internal and external, of pressure to work hard (or not) in mathematics'. Given my background description of David, I am encouraged to believe that my groupings show a measure of validity.

During that interview David said that he would copy and that he would guess the answer. About copying he said:

"If I'm in trouble I would. If I want to get out at break time. If I've been too slow and he says, 'Right, you're staying behind unless you get these answers done.' then, you know, my mates will usually say, 'Oh, here you are.' And they'll chuck the book over and you can copy down the rest".

And concerning guessing he said:

"Well, if I've gone through it once and I'm not happy with the answer. Or imagine I'm doing an exam and I've gone through and he says, 'Right, two minutes left'. So, I've left out one or two answers. I won't have time to do all of them so I just guess the rest".

To me, these seem to be examples of David's belief that events in the short term are what matters.

Some of his responses demonstrate David's belief in self-reliance. This is a belief which can work for success in school mathematics or against it depending on the constellation of beliefs in which it plays a part. In David's
case, where his own beliefs are not ones which would persuade him to work hard, it means that he will ignore external pressures. For example he said that his work is for himself alone and that he is not concerned about what his friends, his teacher or his parents think about how well he is doing in mathematics.

And yet, there was one response which, perhaps, shows that the sheer delight in learning which David demonstrated in the first interview has not completely disappeared. In response to the question, 'What pleases you the most. Getting the answer right or finding out a way of working out the question' he said:

"Finding the way of working it out because you can go so smoothly, you know. Like, I've forgotten what it was, but I used to be able to do this thing quite quickly and I thought it was so smooth the way that they managed to do it".

Perhaps there is hope that in time some of David's beliefs will change and he will return to learning mathematics. Perhaps after he has left school. During his second interview he said:

"I'd save up and take all my exams again if I knew I could get into the army".

Before leaving David I think it is worth referring to something else he had to say in the second interview. I asked him about what sort of person succeeds in mathematics and he said:

"That's a person in my class. Not class as in
school. But not the upper class or the lower class. The middle class. Do you know the expression? He tries but he is still a laugh. Goes out every night for a game of football but has a brain for learning. Admittedly he mucks about a bit. But us boys will be boys. And he tries. As well as talking to his mates in class and being a lad. That’s what I’d like to do. I’d still have time for my mates and also do maths as well”.

When I asked him about what sort of person fails he replied:

“Well, I knew this kid. He’s gone from the school now. He was too much. You see, he used to muck about too much. There’s a limit to mucking about. There’s fun and there’s going too far. He went too far. He got put down a set and he didn’t even work there. And then he just left maths alone and he couldn’t do it very well”.

He followed this with a description of what it needs to learn mathematics. He said:

“To learn maths you’ve got to be a laugh still. Not too, sort of, heavy. Not saying, ‘sorry, I’m staying in to do four thousand pages of maths work tonight.’ He’s still got to be your mate but he’s different when he sets foot into the maths classroom. He can still talk to his mates in there but he tries harder”.

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I have often wondered if the failure to whom David was referring was, in reality, himself.

I would suggest, with all the advantages of hindsight, that, without a conscious decision to do so, David is taking from school just what he wants from it rather than what the school system believes he should take. But I also believe that David has set his sights lower than he might have done and that what he believes he needs could have been influenced by others had the school system been more flexible with greater opportunities for individual pupils to follow their own interests.

Furthermore, I think that perhaps, even with all his general beliefs working against it, David could have been successful at mathematics in a system which was differently organised. If, for example, there had existed the opportunity for the sort of individual help which David believes would help him to be successful. I asked him what it would need for some of the mathematics topics to become easier and he replied:

"If I was sat down in a room all on my own and somebody talked to me slowly about it. And then they showed me examples of how to do it and gave me a couple of tries. And then, I think, I could do it".

I have a suspicion that many of those labelled by the Cockcroft Report (1982) as being able to, ‘advance only a very short distance along the mathematical road during their years at school’ are pupils like David.
8.2 Elfrida

Elfrida has been in the top set for mathematics since the pupils were first set for the subject in the second term of the first year. For a time she was only middling in her exam position in the set but I have watched her move steadily up until now, at the end of her fourth year, she is in the top ten out of approximately three hundred and sixty pupils in her year.

I have chosen to discuss Elfrida because, as with David, it is possible to chart her development quite clearly and to suggest which of her beliefs have helped to ensure that it is taking its present course. However, it is less easy to suggest the sources of Elfrida's beliefs than it was David's because, unlike him, she is a pupil who answers questions in the abstract and carefully structures her responses.

I feel sure that this is something that Elfrida has consciously learned to do. I have watched its development over the years. During the first interview she looked permanently anxious and was, at least for a time, slow and hesitant in her replies. Only gradually did I begin to realise that although there was a degree of anxiety, what I was observing was mostly the result of intense concentration as she carefully gathered her concepts together and chose the words to express them.

By the time of the second interview things had not changed greatly. Elfrida was still nervous but, although I did not realise it at the time, she had by now developed the facility for expressing her concepts clearly and precisely, to a sufficient extent for it to be noticeable when I compared the tape recordings and transcripts of the two interviews. A few weeks later, when she took part in the video-recorded problem solving sessions I noticed that, working with her friends, she was more nervous than when
talking to me and equally careful about her choice of words. The approach appeared to be becoming habitual.

The third interview showed a great difference. A degree of nervousness was still evident but although Elfrida was still choosing her words with care, she was doing so with greater speed and confidence. What had seemed to need a tremendous effort in the first year looked very natural by the third.

I have strayed somewhat from my initial aim which was to indicate that the abstract and structured responses made by Elfrida led to my learning rather less about her background than I did about David's and therefore, while I can say a great deal about her beliefs and attitudes, I can say very little about what lies behind them.

During the first interview one of the things which I found notable was her eagerness to develop independence. I gained the impression that this was something in its early stages and that in earlier years Elfrida had probably been eager to please her teachers but I have nothing specific on which to base this and it must remain conjecture. Nor, of course, can I suggest why the belief that this is a good thing was developing at this particular time. I can say only that it grew more pronounced and more clearly defined in later interviews.

There were two constructs which she developed and which correlated very closely. The first one was, 'Subjects where you are in charge of yourself/ where the teacher is in charge'. She said:

"In science you have an experiment and you're in charge of that experiment. And with P.E. the teacher's not there to say you did that wrong".
Later she said:

"In P.E. you're in charge of the team, if you're the captain, and the teacher just guides you along".

The second construct was, 'Subjects where you move about/where you just sit down.' Concerning this she remarked:

"In science you have to move about and so you're in charge of yourself. But with maths, you sit down and the teacher tells you what to do and you get on with it".

It seems quite clear that both of these constructs are really part of a higher order construct which is concerned with autonomy. In subjects like science and P.E. as well as metalwork and needlework which she also mentioned, dependency on the teacher for learning is less obvious than it is in the more academic subjects.

When the time came for the second interview I already knew that Elfrida was in the top set for mathematics so I was a little surprised when she rated five of the eighteen topics as difficult and two as rather difficult. In trying to sort this out I learned that she believed mathematics to be a difficult subject for her and also discovered two possible sources for this belief.

She had rated angles as very difficult and when I asked why she replied:

"Well, you look at it and find you can't really do it plus I've never really been properly taught how to do angles because the teacher in the junior school just gave me the
paper and expected me to learn how to do them. So I've always been afraid to do angles".

I asked if she was still afraid and she replied:

"My mum's shown me how to do them and it's brought it down but there's still something there that makes me afraid to do them".

And yet, on further questioning, she admitted that she now rarely made mistakes when answering questions on angles.

This was not a trivial matter to Elfrida. The experience was still showing its mark by the third interview when she had been holding her own in the top set for over two years. Then, in response to my asking if mathematics needs to be taught in a different way to other subjects she replied:

"Perhaps going over it ten times if necessary if a child doesn't understand it. It could do with a bit more showing how it's done. I don't get it first time. I have to take about five times for me to understand how. Some subjects, like angles, I just can't grasp the first time".

A little later, talking about topics she didn't like, she immediately said, "Angles". And then talking about what she gets out of her mathematics lessons she said:

"I get to know how to do them and I understand them better each lesson. And I enjoy some of the topics that we do and actually look forward to the next lesson. But
some topics I really hate and I dread going to them because I don't understand them. Like angles. But I am getting better at angles though".

So one possible source for Elfrida's belief that she was not very good at mathematics is that she had, in the junior school, had an experience with one topic which was sufficiently unpleasant to undermine her confidence in her ability in the whole subject. Given her record, throughout her school career, it may well be that this was her first, and perhaps only, significant experience of failure and it left its mark.

But the fact that it could leave such a deep mark ties in with the other matter I encountered which may have been instrumental in convincing Elfrida that she was not very good at mathematics. That was her belief that you are not very good at something unless you can do it effortlessly.

The first indications of this belief had come in the first interview. She remarked:

"I'm alright on maths but I find it quite difficult".

And then, having produced the construct 'Subjects I find easy/ difficult' she followed it with 'Subjects the teachers think I'm good at/ not so good at.' I asked her if finding something difficult is the same as not being good at it and she replied:

"Yes, I think so. If I find it easy I can go through it without querying it but if it is really difficult I have to go through it about ten times".
No suggestion here that difficult means something you cannot do. It is merely something at which you have to keep trying.

During the second interview, while talking about positive and negative numbers, number bases and symmetry, all of which she had rated as fairly difficult, she said:

"I can do them but I need to be confident that they are right. If I don't think it's right I won't put my hand up or go and get it marked".

But when I probed a little further I discovered that only a very little need for extra concentration made a topic appear fairly difficult. And the amount of extra concentration needed to understand the topics she found difficult might well have made some other pupils delighted with their own ability.

The third interview demonstrated that Elfrida's beliefs about her ability in maths were being modified a little by her success over the years but she was still unsure about it. She said that lack of noise was particularly important to her in mathematics. She said:

"Not so much because I don't find maths easy. I don't find maths hard, sort of. I'm in between. I have to work at my maths and I don't have to work on other subjects apart from my French and I need some concentration for that as well".

And yet, on that occasion she still managed to sound dubious when she said:
"I’ve been told that I worry unnecessarily about maths".

Furthermore she was even surprised about her recent success in her mathematics exams saying:

"I’ve done better than I thought I’d done. I was quite pleased, even though it’s not one of the best marks that I’ve achieved".

So, the next thing is to understand why, if Elfrida considers herself to be far better at other subjects than she is at mathematics, she continued to make an effort to such an extent that she eventually reached the top ten in her year. As might be expected the answer to this lies in a mixture of attitudes and beliefs. Firstly Elfrida approaches all she does with a determination to succeed. This is not confined to mathematics or even to school. It pervades her whole life. As she said to me in her third interview:

"I’ll have a go at anything. And if I can’t do it, I’ll perhaps work on it and try and get there".

In the second interview talking about what leads to success in maths she said:

"Studying hard. Work comes first and not mucking about".

And about being competitive she said, in the third interview:

"Yeah, we do it. My maths class is very
competitive 'cos there's so many bright kids there'.

And again, talking about her ability she said:

"I know that I'm not so clever as some people in my class for maths but it doesn't stop me from trying my hardest. You know, I don't give up because I'm not the top of the class. I still try, you know, and even if I'm just half way in the class, it doesn't really matter, 'cos at least I'll know I've tried".

Almost her last comment in this interview was:

"Even though I may be one of the top in the class for some subjects I don't think of myself as that clever. I always work hard and try to aim a bit higher".

So one aspect of Elfrida's success is her general attitude of determination to succeed in whatever she does including mathematics. And one thing that informs that attitude is the belief that if you keep trying you will eventually be successful. Furthermore, I feel sure that this belief interacts with her belief, mentioned at the beginning of this profile, that she should behave independently.

But there are two other components to her success which are almost impossible to look at separately. One is her desire to show other people that she is both working hard and succeeding and the other is her fear of losing face. I will try to deal with them separately but I stress that they seem to work hand in hand.

Most indications of the former come from the third
interview. I asked Elfrida who she felt she was doing the work for and she replied:

"I think I do it for me because I want to get a good job and I want to stay on at school but I feel that I'm doing it for the teacher as well because I feel that I want to show her that I want to do it and I can do it".

Later, when I asked if what the teacher thought about her progress in mathematics mattered to her she said:

"Yes. To show that I'm working. You know, I'm working to my standard. It's just an overall impression. I want to give a good impression to the teacher that I can do it and I want to do it".

When I asked about her concern about her friends' views about her progress she replied:

"I think it's competition. That I want to show them that I can do it. But I don't know. Not so much my friends because if I'm stuck my friends will help me. You know, I'll ask them how to do it but I want to show them that I can".

Her belief that it is important to show other people that you are doing well even showed itself in her belief about why we do examinations. She said:

"I think it's to show the teachers what
you've learned during the year and what you've understood".

Elfrida's attitude towards her friends indicates something of the extent to which the belief that she should demonstrate her ability is tied up with her desire not to loose face. This showed up again when I asked her if she was concerned about what her parents felt about her progress in mathematics. She replied:

"A bit, but not so much as my friends or my teachers because if I'm stuck at home then usually my mum has a go".

The implication seems to be that you do not have to prove yourself so much to those who are clearly sympathetic to your needs although, where it concerned her friends, she needed their help, but not at the expense of their believing her to be incapable.

The first indication I had of Elfrida's belief that it is important not to loose face came in the second interview when she was explaining her experience with angles in the junior school. I asked her why it made her afraid to do them and she replied:

"Because she made me sit there and do them and it makes you nervous that if you don't do it people are going to say, 'Oh, she doesn't know how to do it.'"

I asked why it mattered what people might say and her response referred to her present experiences in the secondary school. She said:
"Well, we are supposed to know everything, or practically everything. It makes it different. Because I'm in the top set and the pressure's on".

I feel sure that not only is Elfrida's belief that she should not lose face bound up with her belief that she must demonstrate her success, but that both are closely linked to her belief in her own lack of ability in mathematics. I referred earlier to her remark that she would not put up her hand or go out to have her work marked unless she thought it was right. It seems highly probable that this is as much to do with saving face as it is with lack of confidence.

There were a number of references to not losing face in Elfrida's third interview. I have already suggested two indirect ones but a more obvious reference was made when she said that she did not find it easy to answer questions in front of the class because:

"You feel that if you don't get the question right you're going to get picked on and, well, sort of joked at".

I felt that even in our interviews Elfrida believed herself to be vulnerable in this respect and the extent to which she opened up to me was, for that reason, very heartwarming. I had the impression that one tiny indication of censure from me would have ended any feeling of trust that I had managed to build. It made the interviews something of a trial for me as well as for Elfrida. At the end of the third interview I asked her how it had been. She replied:

"It's a bit nervewracking."

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I apologised but she said:

"It's alright. I'm O.K. now but I got in all shaking. But I think it's a good idea what you're doing. That we should be talking to you".

A brief recap here will indicate the constellation of beliefs and attitudes which I believe have helped towards success in school mathematics for Elfrida. First, a general attitude of determination to succeed in all her endeavours including mathematics. That attitude is informed by a belief that if you keep trying you will be successful and is influenced by her belief that you should behave independently. Second, her belief that you should not lose face together with the belief that you should demonstrate to others that you are both trying hard and succeeding.

I think there is a need to explain more clearly the part which I understand these last two beliefs to play in Elfrida's success. I hinted earlier that I thought both were inextricably linked to her belief that she lacks ability at mathematics. She continued to work in spite of that belief because she believed that she could eventually be successful if she tried. However her belief that she should demonstrate her efforts and her success, together with her belief that she should not lose face, led to her working far harder than was needed for her to be able to overcome any handicaps she believed herself to be suffering under because of her lack of ability. In a sense her very real success has come about because her beliefs have continually led her to underestimate herself.

However that does not mean that I think that if Elfrida now realised this she would stop striving for success. Not only does her determination to do well maintain her efforts
but there are other beliefs which foster them.

One is her belief that you grow to like things which you are good at. Discussing the sort of person who most likes maths she said:

"I think it depends what sort of person you are. If you go into each subject and work at it, even if you aren't that clever at it, then I think you will come to enjoy it".

She had not always believed this. During her first interview I asked her if there was a relationship between liking a subject and being good at it and she answered:

"Not really. I can do music but I don't really like it".

However, by the end of the third year she had decided to take music as one of her options. She told me that although she enjoyed doing all her option subjects she had chosen most of them because they would lead to needed qualifications. Music was her one indulgence which she had chosen purely for pleasure.

And Elfrida's belief was, perhaps, self-fulfilling. She has grown to like all the things at which she had worked hard and successfully, including mathematics. When, during the third interview, I asked her what she got out of coming to school she replied:

"Well, most people will probably say the opposite but I enjoy going to school as well".
She added:

"I meet my friends and I know that, by going to every lesson, in the end I'll achieve something for what I want to do. Because I don't want to be on the unemployment list all my life 'cos I think it's a waste of time. And so I want to use what I've got to achieve something that I really want".

That comment also highlights the fact that Elfrida sees school not only as a place to enjoy learning but also as a means to secure and interesting employment in the future. And to that end she is willing to defer present gratification.

She had clearly considered all of this by the first interview when she was only twelve years old. She stated, during that interview:

"You do maths for later on to get a job".

It is likely that she had heard this view put forward by her parents and other adults but she did seem to have internalised it, however unthinkingly.

Concerning deferral of gratification, one of her constructs at that time was, 'There is an immediate end product/ You wait for the end product.' She explained:

"In needlework and metalwork you're making something that's going to finish with an end product while you're still at school. In history you have to wait to get an O level or an A level".

But she made a further remark which may provide a pointer
to why she believes she should make people aware of her progress. She said:

"You do have to wait but if you are good at it somebody's going to tell you and then you'll know what the product will be at the end".

So, the combination of a number of beliefs and attitudes has led, in Elfrida's case, to sheer hard work both for the here and now and for the future. I cannot prove that she would not have been able at mathematics without them any more than I can prove that a different belief system would have led to ability at mathematics for David but I believe I have provided circumstantial evidence for both.

Before I leave Elfrida I will comment briefly on her responses during the third interview which helped to form the categories in appendix F. As I mostly did with David, I will leave the reader to interpret the categories in the light of his or her interpretation of my description of Elfrida. She is pupil number three.

It is clear that Elfrida has more beliefs working for success than I have mentioned up to now. As with many members of her set she subscribed to a large number of categories which discriminated in favour of the top sets in my grouping, 'Beliefs about the nature of mathematics and how to go about learning it' but very few of those which discriminated in favour of the bottom sets. I have the feeling that, in Elfrida's case, those beliefs are more likely to have arisen as the result of a determined search rather than to have come about through serendipity.

I find it quite interesting that, for the rest of the groups, Elfrida scored nil on those categories which discriminated in favour of the bottom sets. I find this very
much in keeping with what I have written about her and, again, it encourages me to feel that my groupings have some degree of validity.

8.3 Jennifer

I spent some time deliberating on whether or not to include Jennifer here because hers is a very clear case of maths phobia and that has been well documented in the literature. However I decided to do so because the interviews give interesting insights not only into her problem and the way it affects her but also into the attitudes and beliefs which are the concern of this study. Furthermore, even by the first interview, when she was only twelve, she had obviously thought hard and long about her difficulties and, as a result, she was able to provide some very thoughtful comments.

There is a further, but minor, reason for my wanting to write about her and that is that, hopefully, she may be on her way to overcoming her phobia. It is pleasant to be able to discuss someone who is overcoming a handicap.

It would have given me great pleasure to have been able to help all the pupils in return for what they have given me but that was not practical and, anyway, most would not have wanted it. I felt that there was something I could give to Jennifer so, after her third interview, I talked to her for some time about maths phobia and suggested ways in which she could overcome it. Later her mother telephoned me and I also talked to her about it. Some weeks later it was decided that Jennifer should have extra lessons outside of school to help her catch up while she was developing a more positive attitude.

That took place one year ago. Recently Jennifer informed
me, with great delight, that her examination position in mathematics had improved dramatically. Later I looked at her report for this year and I was very impressed. Jennifer has always had glowing reports for every subject but mathematics, but her examination results, in all subjects, are usually disappointing by comparison with her class work. This year her examination results are also excellent and even her mathematics report is glowing. I find myself wondering if the extra confidence Jennifer has gained as she is overcoming her maths phobia is having a knock-on effect in other areas.

From the first interview Jennifer has always seemed to be a very confident and mature pupil except when she was talking about mathematics. Then she became somewhat upset and bewildered. Upset because she was not successful at the subject and bewildered because she obviously could not understand why. She knew that she was making every effort to learn and she was not used to failure. One of her first comments to me was:

"In my old school every time I had a maths lesson I used to worry about it. I used to be in the top stream when I was in my old school, all through the year and in my infants. Now I've come up here, I've joined other people and they're better than me so I'm in the middle group. I'm not bottom, but I'm not top so I try to work up to it and it's something to work up to. I don't worry about it any more."

And yet, just a few moments later she commented:

"I should have said, in my old school I always struggled to get to the top. But I
managed to get there. Now people are better than me."

I was somewhat puzzled at the time as to why Jennifer should so obviously display her concern to me and yet, at the same time, claim not to be worried. It was only after talking to her again and going back over the tapes that I realised that what she meant was that she no longer worried about going to maths lessons but not that she was not worried about people being better than her. In her second interview she said:

"I don't worry about it as much as in the juniors. Then I used to try and I was really put off maths. I don't know why. It wasn't particularly hard or a horrible teacher or anything. I was just aware that my maths was on that day and I didn't want to go to school. But now I'm O.K."

A little later she said that she did not find positive and negative numbers enjoyable and, because she had just told me that she had now learned how to do them and was pleased, I asked why she did not like them. She replied:

"Well, I can go into a lesson now thinking that we are going to do those and my stomach doesn't turn over. But when I'm doing them I don't have any pleasure. I don't have any hatred."

And during the third interview, when her concerns about her lack of progress were still paramount, she said:
"I'm better relaxed at this school. I used to be really worried about maths in my old school."

Unfortunately she could never explain what made the difference and I was unable to find the right question to provide the necessary insights. It seems to me that her feelings in the junior school must have been quite unbearable if this type of stomach turning experience was good by comparison.

When I began my analysis I wanted to find out why, in spite of her difficulties, Jennifer had managed to stay at the top end of the bottom sets rather than gradually losing ground. And, rather foolishly, I tried to start at that point with the result that I became completely lost. I think I began there because along with my belief that maths phobia was at the root of Jennifer's problems went the unconscious belief that I would be unable to locate the source of the phobia. I asked her, during the second interview, when she had begun to dislike mathematics so intensely. She replied:

"About the third year juniors. I suddenly thought, 'Oh, I don't like maths.' And it got worse".

And, as I mentioned previously, she could provide no explanation for it.

When I eventually realised that I was not going to get any further in my understanding of Jennifer's position until I made some effort to understand what beliefs may have played a part in her phobia I turned back to the data to look at it anew. Perhaps because of her intense anxiety about mathematics, it took me some time and a lot of re-reading of scripts and re-listening to tapes to begin to be able to
build up a picture but eventually I was able to piece together what I believe to be the interacting and, more importantly, the conflicting beliefs which had reduced her to such despair.

Because of the complexity of the situation I shall first say what each of the beliefs was and how they interacted or conflicted and then return to the data to provide some evidence for them.

Certainly by the first year of the secondary school and probably much earlier Jennifer had developed the belief that one should learn for pleasure. She also believed that the purpose of learning is understanding rather than the accumulation of knowledge. Both of these beliefs seem to have been explicit and appear, quite reasonably, to have worked happily in tandem.

At the same time Jennifer had four other beliefs which also appear to have been working in tandem but which were in conflict with the two beliefs I have already described. They were that experts, in this case adults, know best; that you should defer to such experts; that certain school subjects are important for one's future and that mathematics is not a subject that can be learned for understanding. I would add that the last two beliefs probably arose from Jennifer's adherence to the previous two in that she adopted them as her own rather than developing them for herself. Furthermore, while Jennifer's belief about the importance of some subjects for one's future was explicit I feel sure that her belief that mathematics is not a subject that can be learned for understanding was implicit.

Such a situation would be almost bound to lead to problems particularly where implicit beliefs conflict with explicit ones. And the third year of the junior school would seem to be a reasonable time for the beliefs to develop. By then parents and teachers are often beginning to talk about
the need to work hard in mathematics and English because of their importance for the future. At the same time mathematics teaching is becoming progressively more abstract and if, as seems likely, it was badly taught, then Jennifer probably had every reason to believe that it could not be learned for understanding.

Returning to the provision of some evidence for these beliefs, there is no clear evidence that any one belief is necessarily more important than another. I would suggest, however, that Jennifer’s belief in the importance of the expert may well have led her to not even consider the conflict in her beliefs.

I chose the word expert rather than adult for two reasons. One was that in the third interview when I asked her about working, in the videorecorded problem solving sessions, with someone from the top set she said:

"...I mean, you expect her to get the answers right. I suppose she had more authority because she’s in top set. If I disagreed with her I said so but mostly I agreed with her because I thought, 'well, she’s in top set so she must be right'".

The other reason was that Jennifer, and her parents, accepted my diagnosis of her problems in mathematics with great alacrity. I was accepted as the expert and I was bound to be right.

In other words I chose the word expert to draw attention to the fact that it is this apparently greater knowledge which seems to be of importance to Jennifer. But at the time of the first interview it was clear that adults were automatically taken to have that knowledge simply because they were adults and I gained the impression that the
situation had not changed noticeably by later interviews. For the rest of the discussion I shall simply refer to adults rather than experts.

There were two particular references which Jennifer made to understanding and enjoyment during the first interview. The first came when she was talking about subjects in which the group were working alone on topics, rather than being taught as a class. She said:

"I like it and it's good fun. I like topics better because I can put what I want to put and what I'm interested in."

The second came when she was explaining to me about educational outings. She said:

"I like to go on outings because you understand things more. You get the feel of things better. If a teacher tells you something but you haven't been to it then you can't really get it. But if you do go to it you can grasp it more and understand what he's saying or she's saying".

And at this time I also gained some insight into the way she had, by the age of twelve, clearly adopted the views of adults; probably her parents but perhaps her teachers as well. She had explained that she was more interested in learning about the past than the present and added:

"I like the clothes they wore better than the modern stuff. Most people are turning into punks now, unfortunately. They complain that they haven't got jobs but I find it amazing..."
that they can't see it's because they don't
dress appropriate for it. And I think they
were better mannered back in those days. And
people are getting too lazy to do anything
now".

In the course of producing one construct in the first
interview Jennifer referred both to her belief that learning
should be pleasurable and to her belief that adults should be
deferred to. She was discussing events which had taken place
before the group had been set for mathematics and she was
complaining that she never seemed to have the opportunity to
finish any work. She went on to say:

"I feel as if I could go up to Mr. Henry and
say, 'well, I haven't finished it. They may
have but I haven't.' But I can't do that
because he's the teacher and I've got to have
respect for him".

And then she said:

"This may sound like having time to finish
but it isn't. It's just that with music and
history I feel as if I can take it easy and
if I have them in the afternoon I can relax
and get on. We have a mixture of hard work
and fun and it's enjoyable."

The construct she developed was, 'Subjects which are
interesting/boring'. Not surprisingly this construct
correlated closely with her construct 'Subjects I like/
dislike'. Most subjects she both liked and found interesting.
She disliked mathematics and found it boring.
During the second interview Jennifer said that she felt frustrated when she could not get the work right in mathematics. She said:

"Once or twice I've given in but usually I stick to it and it seems I just about conquer it and then we have a long break and we come back to them and I've forgotten them all again and I have to go over and over".

I asked her why she stuck to it rather than give up and she replied:

"Well, otherwise I'd be rubbish at maths and you can't get anywhere in the world if you're bad at maths. The job situation nowadays, you've got to be good at a lot more subjects and maths is a very important subject".

But a little later she provided an insight into the clash between this belief in the importance of mathematics for the future and the belief in learning for pleasure and understanding. I had asked about some mathematics topics which Jennifer had rated as fairly easy. She said:

"Statistics. There's nothing to fret about there. They're quite fun. Relations and graphs are quite easy too. Sometimes I have to think, 'ah, now what does that mean' and then it comes, usually. Route matrices I've done a lot of work on and I understand them. I got a few wrong at the start but I gradually got better and then they came very easy".
I was quite amazed to discover that there were topics which Jennifer not only liked but felt she understood. I asked what made the difference between these topics and the others and she replied:

"Well, with these, they're fun and I couldn't ever see them being used in jobs so they're not that important to me. They're still important because I like them but not as important as the others".

This response was placed in a clearer context a little later when we were discussing topics that are useful in everyday life. After going through all the topics it turned out that, for Jennifer, the really important ones were to do with arithmetic. And these were the ones that she had learned mostly in the primary school.

In a moment I will discuss some evidence for believing that Jennifer saw mathematics as a subject that could not be learned for understanding but before I do I would like to demonstrate that she could at least imagine a different state of affairs. At the end of the second interview, in answer to my question about the perfect mathematics teacher she said:

"We'd have maths twice a week and the first lesson in every week would be one that could be enjoyable. But then, I think that would only be enjoyable to me because the things that I enjoy, some people may not. So, maybe she could find out first the type of things that most people enjoy and do some of those to give a break. But, instead of doing large quantities of things in a short time, maybe do a few things and concentrate on them. Then
you’ve got more time on each one instead of rushing on to the next subject. It seems it just goes on and on instead of going into each subject”.

She added:

“She should concentrate on making the children enjoy maths instead of worrying about it. Then, not just teaching the whole class. Like, the class is a thing, but there are other things inside the class and that’s the pupils so she must concentrate on what the pupils are thinking”.

Perhaps one of the clearest indications of Jennifer’s view of mathematics came in the second interview when she was talking about her difficulties. She said she found the work difficult:

"Because I don’t understand. I do them and I get them right but I don’t understand how I get them right some of the time. Usually I go up and ask the teacher".

Then she said:

"Like, the teacher does some on the board and I look at the board and I think, ‘well, the way she’s done that was so and so’. So, I change the sum on my paper to look like the one on the board. I think, ‘she did that to that so I’ll do that to that’. I think, ‘yes,
I get this’ and then, suddenly, she says, ‘Right, page so and so in the book’ and I think, ‘Oh gosh, she’s ended already. And I thought she was going on for more so that I could grasp it more’.

At the end of the same interview Jennifer made a comment which was partly responsible for leading me to believe that she was unaware of her view of mathematics as a subject that could not be learned for understanding. She said:

"I try to understand it. Most of the time its learning off by heart but I try to understand".

I asked why she learned it off by heart if she thought understanding was important and she replied:

"You don’t think about it at the time and after the subject’s gone and you’re onto something else you think, ‘I wish I’d tried harder at that’. And then, when it comes up again, ‘Oh yes, well I’m going to do it’ and then it goes, all over again".

Of course it is only possible to interpret the comment in the way I have, in the light of knowledge about Jennifer’s success in understanding in all other areas of the curriculum.

But perhaps by the third interview she was beginning to gain some insight into the matter. She said that it mattered more to her to get the answer right than to understand how to work it out but added:

"I wish it was the other way though. It
sounds as though, if you can work it out, you’ll know how to do it in the future”.

While all of this tells us something about the beliefs that contributed to Jennifer’s problem it does not say much about why it was, in face of all her fears and difficulties, that she managed to stay near the top of the lower sets rather than giving up and gradually dropping to the bottom. I gave some indication when I wrote about her saying that, ‘you can’t get anywhere in the world when you’re bad at maths’ but while this was an important factor in her determination to keep trying it was not the only one.

I think that, partly, it was simply that Jennifer was not used to failure and it hurt her pride. In the first interview she said when comparing three subjects:

“I try and aim for something in maths but with science and metalwork I’m really alright because I’m in the top stream. So, I still stay there but I don’t attempt anything like maths. For maths I’m aiming for something. I don’t find it easy to get anywhere. I’ve always tried hard to get somewhere. I find science as hard as maths but I don’t aim for it like maths”.

She was still talking in the same way by the third interview. We had been discussing the fact that she did not like it if people were talking a lot in mathematics lessons and I asked how she felt in other subjects. She answered:

“Well, I talk in other lessons anyway so I suppose I’m one of the ones who annoy other
people but I can get on with my work in other lessons".

I asked what was the difference and she replied:

"Maths is the one I'm trying to work for the most. I'd like to do the best in maths so I concentrate more in maths than other lessons".

But a clue to another possible reason came in the third interview when I asked Jennifer if she was concerned what her parents thought about her progress in mathematics. She said:

"My dad wants me to do really well in maths so I work for him more than my mum. I have to try and impress him in maths".

I asked why and she replied:

"I suppose it's because he's so good at maths and he wants me to be the same as him".

And here, I feel, we've gone full circle. One of the reasons she continued to strive to do well in mathematics was to please her father but her belief that you should defer to adults, and probably particularly so to her father, played its part in her difficulties in mathematics.

It is interesting to note the differences here between Jennifer and Elfrida. Elfrida also wanted to show people that she could do mathematics but there is ample evidence that, while Jennifer's desire arose from a somewhat overdeveloped respect for adults and a consequent desire to please them, Elfrida's came more from her own belief that she should
succeed. And yet, apart from where it was touched by her relationship with mathematics, Jennifer's self confidence appeared to be much greater than Elfrida's and she certainly seemed to be much less beset by self doubt.

There is one more difference between Jennifer and Elfrida which may, perhaps, throw some light on Jennifer's problem. I mentioned that Elfrida had said:

"If I get stuck at home then usually my mum has a go. If I'm totally lost then my mum, even though she can't do it, she'll have a go and try and sort of work it out with me".

Jennifer, on the other hand, told me that her parents could not help her. Referring to her father she said:

"Well, my dad is clever at maths but he's learned different ways from us. Even though he gets the same answer, when we have to work it out we do it a different method. It's no good".

Elfrida appears to have a parent who sees mathematics as something which anyone can approach and make sense of and I think it is likely that this belief has influenced Elfrida's beliefs. On the other hand, Jennifer's comment suggests that her father sees mathematics as a rigid body of knowledge which is handed down. Jennifer has learned one approach to mathematics and he learned another and there can be no meeting of the two. There are a number of indications in her interviews which suggest that Jennifer's beliefs may have been influenced by this.

My previous comment was not intended to be censorious. I have, during the course of my teaching career in mathematics,
met many parents like Jennifer's father and very few like Elfrida's mother. I am sure it is our methods of teaching which are at fault.

As I did with David and Elfrida, I will finish with a final comment on Jennifer's responses during the third interview. Once again I will leave the reader to interpret the categories in the light of his or her interpretation of my description of Jennifer. She is pupil number two.

In the first group, 'Beliefs about the nature of mathematics and how to go about learning it' Jennifer subscribed to more categories which discriminated in favour of the top sets and fewer which discriminated in favour of the bottom sets than did most pupils in the lower sets. This perhaps helps to explain why Jennifer was able to make good progress in a short time when she had some private tuition. Her subscriptions to three of the four other groups were also much more in line with top set pupils than bottom set ones suggesting that maths phobia might well have been her main problem. The exception was group three, 'Feelings about mathematics'. It is possible that Jennifer would now subscribe to different categories in this group.

8.4 Postscript

I think it is important for me to remind the reader of the constructivist framework within which these case studies have been produced. I see my interpretations as reflecting my own beliefs and attitudes rather than something to be laid down in tablets of stone.

However, I did make every effort to ensure that I was not taking off into flights of fantasy. I was continually aware of how easy it would be to make the scripts fit my prejudices. I used two methods to control this. Besides using
my transcripts I kept returning to the tapes themselves to listen to how the pupils had said what they said. And, to check on the background material, I went through my findings with each pupil at the end of the third interview to see if they agreed with me and to change things where necessary.
Chapter 9

CONCLUSIONS AND RECOMMENDATIONS

Introduction

When I began this work I decided to look at beliefs and attitudes together, rather than merely confining myself to the former, because they are inextricably linked and to look at one implies looking at the other. Even though I defined attitudes as being built from beliefs I was of the opinion that it would be necessary to consider both. However, as early as when I began my search for categories I began to realise that my methodology must inevitably lead to a greater concern with beliefs than with attitudes. If, for example, pupils said that they liked mathematics then I wanted to unpack that attitude to find out the beliefs that led to it. There did not, after that, seem to be a great deal of point in packing the beliefs back together and discussing, separately, the attitude to which they led. Consequently almost all the discussion in the body of this writing has been concerned with beliefs rather than attitudes and I will continue in the same way as I draw my conclusions and make recommendations for further work.

I would remind the reader, as I explained in detail in my introduction to chapter three, that I am here using the word 'belief' in a very specific sense, i.e. to mean 'personal construct'. At that time I argued that beliefs and constructs are one and the same thing and that to take this position is in line with Personal Construct theory, and that indeed this was in line with the way the word 'belief' was used in common parlance.
9.1 The process of the study and the uses which were made of the data at each stage

My fieldwork consisted of four stages, as described in chapters four to seven, which built on each other. I began with the first interviews when, using as respondents a group of pupils who had recently started in the first year of the secondary school, I elicited personal constructs about school subjects. The second stage took place in the following year when I collected mathematical data from the same pupils using the constructs of easy/difficult, like/dislike and useful/not useful. Six weeks later, in order that I might obtain data of an observational and oral kind, the pupils who had participated in the two previous parts of the study took part, in groups of three, in problem-solving sessions which I videorecorded. This formed the third stage. Finally, using the data from the second interviews, I developed categories of pupil responses to form a basis for the creation of forty loosely structured questions. Using these questions I interviewed the pupils for the third, and final, time. On this occasion I asked both the questions I had developed and other subsidiary questions which arose during individual interviews.

My main data analysis resulted from the final interviews, and forms part of chapter seven. From the pupils' responses to these questions I developed a large number of categories. The questions seemed to fall into five groups so, once I had developed the categories, I grouped them according to the questions from which they arose.

My main finding was that some of the categories discriminated in favour of those pupils who were in the two top sets and some discriminated in favour of those pupils who were in the bottom three sets. The rest of the categories were neutral in that the proportion of pupils subscribing to
them was approximately the same for top and bottom sets.

By saying that a category 'discriminated in favour' of top or bottom sets, I mean that pupils from one or other of the combined sets subscribed to that particular category in greater numbers than did pupils from the other combined sets.

As another way of looking at the data I later developed four groups from the categories which discriminated in favour of the pupils in the top sets and six groups from those which discriminated in favour of the pupils from the bottom sets.

The data which I collected from the first interviews and from the videorecorded problem-solving sessions provided useful illuminative background information. I used this information mainly to help me to gain some understanding of the reasons why individual pupils had formed certain of their beliefs and, in chapter eight, I provided three case studies to demonstrate this use. However I also occasionally used the data to help me to develop the categories from the second and third interviews.

I made clear, at the beginning of this study, that my stance, both philosophical and practical, is a constructivist one and that while that does not rule out shared beliefs it does mean that each individual's belief system is unique. Chapter seven demonstrates that pupils from top and bottom sets do differ in their beliefs about mathematics but, as I have stressed throughout, the differences are not uniform. As my case studies of David, Elfrida and Jennifer hopefully demonstrate, what appears to be of greatest influence is the cluster of beliefs which each individual pupil holds and the way those beliefs interact.

But old beliefs die hard. I was brought up to believe that research is about generalisations and I confess that, in spite of my philosophical stance, I would feel more comfortable with myself if I was able to provide them in quantity. For, no doubt, atavistic reasons it would reassure
me that I was doing the right thing. But I can, of course, provide very few.

I can, as I shall show, generalise about that which I set out to investigate: whether or not the different belief systems which pupils bring with them to their mathematics lessons influence their progress in the subject. I cannot prove that they do but I feel sure that I have produced strong circumstantial evidence that this may occur. However, the individual belief systems are of much greater interest than the generalisation.

9.2 Findings from the study

I will start with findings which arose from specific parts of my work. Some of the findings came directly from my elicitations but others were incidental. After that I shall relate a number of general findings which come from looking at all the data together.

9.2.1 Personal Constructs of the school curriculum

Because I was using it as background information I did not use the data I acquired from the first interviews for comparisons between pupils. However one thing was quite clear without detailed comparison. Pupils in the top sets for mathematics were more inclined to produce constructs which related more to external factors than were pupils in the bottom sets. The latter were more inclined to produce constructs which related more to personal factors. I gave examples of this in chapter four. I speculated that the pupils providing constructs relating to external factors may have adopted the cultural belief that one ought to try to be
objective and I suggested that such a belief could be useful for the learning of school mathematics as it is, in many cases, presently taught.

9.2.2. Behaviour categories that distinguish between top and bottom sets

From the data from the second interviews I identified a number of general categories which were subscribed to by all of the pupils in the study in either a positive or a negative way. Three of those categories discriminated between pupils from the top sets and pupils from the bottom sets. The first category was concerned with whether pupils could or could not work in mathematics lessons when there was noise and other people were messing around. Ten of the fifteen pupils in the bottom sets said that they could not while nine of the fifteen pupils in the top sets said that noise and messing about did not trouble them.

I discussed this in detail in chapter five and pointed out the potentially damaging consequences. However, I do not suggest that this should lead to attempts to change pupils' behaviour but rather to a change of teaching methods to those which, by encouraging a more active pupil involvement, will lead to the reduction of noise and messing about in the classroom.

The second category concerned whether or not pupils give up when they find mathematics difficult to understand. Not surprisingly, thirteen of the pupils from the top sets said that they kept trying while ten from the bottom sets said that they gave up.

I found the third discriminating category a somewhat surprising one. Ten of the fourteen pupils in the top sets said that being able to do the work is more important than
understanding in mathematics while nine of the fourteen pupils in the bottom sets said the opposite. Unfortunately there are a number of different possible interpretations of this category and it is, therefore, not possible for me to draw any firm conclusions.

9.2.3 A distinction between arithmetic and mathematics

Statistical results arising from analysis of the pupils' ratings of mathematical elements provided two specific findings. The first was that, in general, the pupils in my study group preferred what I called maths topics to arithmetic ones and found them easier. However they believed arithmetic topics to be more useful. As used here, the term 'maths topics' refers to any algebraic or geometric topics.

Looking at this finding rather more closely, I noticed that there was less of a difference between mathematical and arithmetic topics when only arithmetic topics using whole numbers were considered. It was, in particular, topics to do with fractions and decimals that accounted for most of the difference.

Nevertheless, and this was the second finding, however one looks at the statistical data it is clear that even though the pupils from the bottom sets, as a whole, believed maths topics to be of less use than arithmetic topics than did pupils from the top sets, the former also found maths to be slightly more enjoyable than the latter. This finding led me to suggest that if bottom set pupils were given more opportunity to work on maths topics they might develop a greater liking for mathematics as a whole.
9.2.4 Is mathematics perceived as different from all other subjects?

An interesting finding which came, in the main, from the second interviews was that, like the pupils to whom Hoyle (1982) spoke, the pupils in this study frequently commented on the fact that any difficulties they experienced in other subjects they also experienced in mathematics but to a greater extent. However there were variations. A number of the pupils said that they found foreign languages just as difficult as mathematics and others said they found them only marginally less difficult than mathematics. It is quite probable that unsuitable teaching methods are the culprits for both mathematics and foreign languages and the fact that, nationally, the situation for languages is beginning to improve as methods change with the introduction of G.C.S.E., gives credence to this.

9.2.5 Can pupils judge their own ability?

As a result of the second interviews, I can also say that in general the pupils' perceptions of their ability in school mathematics accorded with the sets in which they had been placed. Furthermore, scrutiny of their examination papers enabled me to establish that their perceptions were, generally, in accordance with their performance. But, as I said in chapter five (5.7.2) there were four pupils whose perceptions did not show a good fit with their positions and, as I hope I demonstrated with the case study of one of them, Elfrida, that is surely of much greater potential interest than the generalisation.
9.2.6 problem-solving abilities

The results of the videorecorded problem-solving sessions suggest that closer attention needs to be paid to the relationship between pupils' perceptions of their mathematical abilities and their actual performance.

Although the reason for conducting those sessions was to provide observational and oral data to corroborate or refute the interview data they also, incidentally, provided data about the pupils' problem-solving abilities. To my surprise I found that the relationship between set and ability no longer held good. The ability of some of the lower set pupils at problem-solving was much better than might have been expected.

I realised that two different concepts of mathematical ability were under consideration. That considered in the second interviews used an arithmetic approach involving a considerable amount of algorithmic learning while the second one used the concept of mathematics as problem-solving. I concluded that instead of discussing attitudes towards mathematics in general it might be necessary to separate attitudes towards routine work and attitudes towards problem solving.

9.2.7 problem-solving behaviour

I drew some other interesting and particularly thought provoking conclusions from my observations of the videorecordings. I became aware of differences in problem solving behaviour as I compared the videorecordings of each group and, as I explained in chapter six (6.6.1) I even made abortive attempts to identify and quantify examples of such behaviour. That it was a pointless exercise in that
particular context does not mean that some of the behaviours are not themselves worthy of consideration. It does mean, however, that they can be discussed only in an impressionistic way.

I listed thirteen relevant categories in chapter six and I will consider five of them together as a group. They are as follows:

- Not listening carefully to what other pupils had to say about a problem.
- Discussing a problem without pause for thought.
- Not attempting to explain their ideas to other pupils.
- Not re-reading a problem as the discussion progressed.
- Deciding on a solution before a problem had been fully discussed.

The reason for discussing them as a group is that, on reflection, they were all part of behaviour which, at the time of the videorecorded sessions I had, in my notes, labelled as 'early closure' and which is, of course, the final one of the behaviours I described above. This was my shorthand way of describing a situation where pupils appeared to come to a rapid, and usually inaccurate, decision about the answer to a question.

I am not suggesting that each of the behaviours mentioned above were involved on each occasion. But when I analysed the videorecordings I did notice a tendency for all, or nearly all, of them to be present on those occasions which I had noted at the time.

I have already pointed out that these observations are impressionistic. For that reason I did not discuss them in chapter six. I am raising them now because I think it would be both interesting and useful for such behaviour to be
understood. It seems reasonable to assume that a number of different beliefs are involved and are working together, or even against each other. To know what they are, and the extent to which they vary from individual to individual might help in the task of encouraging pupils to look more deeply into the nature of a problem and of discouraging them from deciding, too rapidly on the basis of too little evidence, that they have the solution. Although not confined totally to the bottom sets it does seem, not surprisingly, to be behaviour which is connected with failure at school mathematics.

However I am not convinced that this behaviour can always be attributed to a pupil's belief that the problem is fully solved. With some pupils it did seem, on occasion, that they believed that they had exhausted the problem-solving process at a point where much more thought was still needed. The expressions on their faces appeared to indicate pleasure at a job well done and/or they checked with each other to make sure that they were all agreed that they had come to the end of the process. But the behaviour of five pupils, only two of whom were in the same group as each other, seemed to be different in kind. These pupils appeared to be quite happy with the idea that the answer was somewhere in the right area. There were comments like, "Yeah, that'll do", and, when the others continued to deliberate, "Come on. We've done that one. Let's get on to the next one".

The most obvious explanation would be that the pupils were bored and wanted to get the whole thing over with. For two pupils I think this is possibly the case, at least as far as the later questions are concerned. But it does not account for the same behaviour when the work was being approached with apparent enthusiasm. And it does not account for the behaviour of the other three pupils.

In considering this problem I am continually reminded of
an article by Maier (1980) in which he discussed the apparently poor mathematical skills of American students. His main argument was that the way that people handle mathematics-related problems which arise in everyday life is quite different to the way they answer the, apparently, real world problems posed in school. There is ample evidence (Carraher, Carraher & Schliemann 1985; Lave, Murtaugh & de la Rocha 1984) that this is so but it is a related argument of Maier’s of which I am reminded. He pointed out that in everyday situations people frequently rely on rough notions of calculations rather than on precise answers.

Most pupils are probably aware of the distinction even if they do not think the matter through. Furthermore they accept that in school one is expected to work out exact answers. But perhaps not all pupils share this belief, or they may accept it in practice to only a limited extent. Performance in school mathematics would suffer where this was the case.

A belief that, for some problems, an approximate answer would suffice would explain the behaviour of the pupils to whom I referred above. And such a belief could also account, at least in part, for the rather dramatic difference between the top and bottom sets in their answers to the question, ‘would you ever guess the answer in maths?’ Nine of those in the bottom sets, but none from the top sets, said that they sometimes guess the answer. When I asked further questions the responses indicated that these pupils thought of them as pure, rather than calculated guesses. In contrast, the responses of twelve pupils in the top sets and two from the upper end of the bottom sets indicated that they would occasionally make an estimated guess but only when they were not confident that they had worked through a question with total accuracy.

At the time, I accepted the pupils’ definitions of ‘pure guesses’ but I have since come to wonder if at least some of
those definitions may have arisen as the result of conflict between the belief that, in problem-solving, approximate answers are sufficient and the demands of school mathematics for total accuracy.

If this is the case then the difference between the pupils would not be as wide as their responses suggested. The pupil who talks of making a calculated guess would be consciously doing so after attempts to find a totally accurate answer had failed. The pupil who talks of making a 'pure guess' may, because of an unconscious belief that total accuracy is not necessary, be actually making an estimation.

9.2.8 Culturally based beliefs

Before leaving the findings which arise mainly from one part of the study I have one more from the problem-solving sessions. In chapter three I discussed the finding by Mitchelmore (1980) of culturally based mathematical beliefs. I found evidence of such beliefs by the pupils in this study. When discussing a question about a mother buying Christmas presents for her children to give to one another a few pupils decided, often after much deliberation, that the mother would also have to give a present to each child. The introduction into the problem of a cultural belief led to the wrong answer. There was nothing in the wording of the question to suggest that it was necessary.

9.2.9 Success or failure in school mathematics

I shall next discuss some findings that arise from bringing together different parts of the study. The first of these was, perhaps, my most general but also my most
impressionistic finding across the study. It was that success or failure in school mathematics appears to be closely related to the extent to which pupils appear to believe they are in control of themselves in the school situation combined with a determination to do well in all school subjects and a belief that you grow to like the subjects in which you do well, rather than that you do well in the subjects which you like. I have deliberately not chosen to talk about internal and external locus of control because the literature on that topic tends to suggest that these are general characteristics.

I found that there were pupils who indicated that they did not feel in control of themselves in school but who felt very much in control of their lives outside of school hours. Such pupils tended to make comments such as, "Well you can only do your best", which, in context, suggested a willingness to settle for that which could be achieved without any great effort.

I also found pupils who felt quite in control of themselves at school but who did not demonstrate any desire for general success. Like David, they tended to believe that it is best to concentrate on those subjects which you most enjoy and George was the only one to say that mathematics was his favourite subject.

Most of the pupils who indicated that they were in control of themselves and were determined to do well in all subjects clearly stated that they were planning for the future either in terms of specific occupations or because they wanted to gain qualifications which would lead to further education. Other pupils made comments about the future but were less ambitious. It seemed to be the belief that you can learn to enjoy what you are good at that made the difference. None of the more successful pupils gave mathematics as even one of their favourite subjects and none
said that they found the subject easy. But they did say that they quite liked mathematics although it was not a subject that they would choose to do for pleasure but only because it was needed either for the work they hoped to do or in order to be eligible for a higher qualification.

9.2.10 The importance of the individuality of each pupil

My final conclusion is included to demonstrate the importance of the background data relating to individual pupils and to point up the limitations of the use of generalised categories. I am able to draw this conclusion in the light of recent information about the pupils’ present progress.

The pupils in my study are now in the fourth year of their secondary education and they have recently had their end of year examinations. Before concluding my work I decided to look at their examination positions in order to see if there were any noticeable position changes which might be associated with the categories to which each pupil had subscribed and with the background data which I had collected on each of them. Since I also kept records of their positions in previous years and have read all their school reports, up to and including this year’s, it seemed reasonable to assume that drawing conclusions about such associations might be feasible.

Unfortunately, while nevertheless useful, the information about examination positions is not entirely straightforward. For the teaching of subjects which are taken by every pupil, the school divides each year group into halves and each half studies those subjects at different times. The basis for division is such that certain school houses work together. At the end of the third year of the study pupils’ time in the school a change in numbers made it necessary to reorganise
the division between the two halves, so that the size of the group which contained the study pupils was changed. This made it impossible for me to look at the pupils’ year positions across time but I was still able to look at the relative positions within the study group.

A second limiting factor is that, after the first year, the pupils do not take the same examination. However, sets one and two share the same examination paper as do sets three and four so this is not a great problem either. The combinations are very similar to the way I have considered the pupils when taking them as a group.

Several pupils have now changed their positions. In order to demonstrate the importance of individual background data and the limitations of the use of generalised categories to which I referred above, I will discuss four of them here. Two are cases where the position of the pupil has deteriorated and two where the position has improved. I have, of course, already made reference in chapter eight to similar changes in the positions of the three pupils whom I used for case studies. When referring to those pupils, I used fictitious names. I will do the same for these four pupils.

George (pupil number ten) was, for the first two years, virtually at the top of his year in mathematics. By the end of the third year he had dropped a few places and his position is now in the bottom half of the top set. As I talked to him in the first two interviews the background data I was hearing made me doubt that he would be likely to sustain his position. Basically this was because his approach appeared to be almost totally instrumental.

I am, here, including two meanings given to the word ‘instrumental’. The first is the meaning given by Skemp (1979) when he says:

"Instrumental understanding in a mathematical
situation consists of recognising a task as one of a particular class for which one already knows a rule”.

The other meaning is that given to it by Mellin-Olsen (1981). He argues that:

"The learner often possesses relational understanding of some knowledge, for which he sees no use, outside its importance as 'school knowledge'".

He goes on to define instrumentalism as:

"...a rationale for learning, connected to the role school has as an instrument for future schooling and employment".

The description seemed to fit George perfectly. I am sure he possessed relational understanding to a certain degree but, from what he said, I am equally certain that he believed that 'knowing the rules' was what mattered. He said that mathematics was his favourite subject and the one at which he was the most successful but he was quite definite in his preference for 'useful' topics and quite definite in his claim that the sole purpose for school was to prepare one for the world of work.

One thing in particular is worth recounting. During the second interview it became clear that George knew how to divide fractions but, no doubt in common with most other people, he had no idea why the method worked. This led to a discussion about the place of understanding in mathematics and I asked him if it ever bothered him when he lacked that understanding. He answered:
"Not at the moment. They will explain it all when we get further up the school".

I wonder if he is still waiting?

Table 7 in appendix F shows that George did not subscribe to as many categories discriminating in favour of the top sets as did many of those very close to the top of the top sets and did subscribe to rather more of those which discriminated in favour of the bottom sets. Such numbers are, of course, only indicative. I mentioned them because in this respect George was not very different to Bernard, pupil number twenty eight, but Bernard, unlike George, has improved his position from the second third of the top set to the point where he is now joint first in the year.

I have chosen to mention Bernard because his case draws attention to the fact that beliefs and attitudes are not static. Of course, because I have not interviewed him recently I am not in a position to say in what way his beliefs have changed or even that they have. However, his report indicates an across the board improvement that has surprised and delighted his teachers. It may be significant that, nearly a year ago, Bernard was absent from school for almost a term because of a broken leg. In that time he had private tuition. Perhaps the different approach that this involved or the time that Bernard had, while incapacitated, to consider his approach to school led to useful changes in his beliefs.

Derek, pupil number twenty three, has gone steadily down throughout his four years. In the first year he was in the top set but then he was moved down to the second set where he still remains. However his work in mathematics, although not in other subjects, has now deteriorated to the point where he may well be moved down to the third set when he starts the new academic year.
The categories to which Derek subscribed show that he was particularly low on those which discriminate in favour of top sets in the first group, 'Beliefs about the nature of mathematics and how to go about learning it'. This group does appear to be of greatest importance together with the fourth one, 'General beliefs, not necessarily to do with mathematics' where Derek also subscribed to very few categories which discriminate in favour of top sets. The background data on Derek also suggested that his work might deteriorate.

Dorothy, pupil number one, improved her position this year to such an extent that, although she is in set two, her position was higher than many of those in set one. In fact her position is higher than is George's. There is nothing in the categories to which Dorothy subscribed which indicates that this would be likely and that could be levelled as a criticism of my study if it were not for the fact that it is constellations of categories that seem to count most - and then only when they are considered in the light of background material.

It is the background material which is the most enlightening in Dorothy's case. She clearly felt very much in control of herself and wanted to succeed at school in order to get good employment in the future. This was for herself but also to please her mother. However, she tended to underestimate her need to listen to, and be helped by, others. This showed up particularly well in the problem-solving sessions where, on several occasions, she developed an argument based on false premises and talked down the other two pupils as they tried to point out her errors. But one year later, in her final interview, she showed signs of becoming aware of her shortcomings. Previously she had switched off her attention if she believed that the teacher was explaining something she already knew about. She informed
me that she now appreciated the need to pay closer attention. She also said that she had started to reconsider the day’s work before going to sleep at night in order to see how she could improve on her ability. Her change of belief about how she should approach her work seems to have paid dividends.

9.2.11 What can teachers learn from my study?

My discussion of the relationship between categories and background data, including such specific items as examination results, brings me to the use to which this study might be put. I hope that, methodologically, it might have something to offer to other researchers. But I would like to think that its main contribution will be to inform practising teachers of pupils of all ages, and students who are preparing to teach, of the need to consider the important role which individual beliefs play in the learning of mathematics.

Throughout this work I have been looking at the beliefs and attitudes which pupils bring with them to their mathematics lessons. This has, of course, been done by others but, to the best of my knowledge, there has been no other study which set out to develop general categories of beliefs from responses which a number of pupils gave in answer to specific questions. In particular the categories which I developed from the data from the third interviews, and which I discussed in detail in chapter seven, were developed for the specific purpose of making it possible for me to find out if, for this group of pupils, there were differences in beliefs about mathematics between the pupils who were in the top sets for mathematics and those who were in the bottom sets. Now that this study is complete, the categories have no further use except as a demonstration of those differences.
At the individual level, it is of no advantage to produce a list of categories and find out those categories to which pupils subscribe. It is the individual beliefs which matter and these can be found only by discussion with, and observation of, the pupils themselves. Furthermore, since beliefs may change over time, it is not enough to become acquainted with a pupil’s beliefs at any one time and assume that they will remain constant.

And lest teachers argue that they would have no time for these lengthy interviews let me stress that they are not needed except for studies such as this. I spoke to pupils for less than four hours in a period of three years. Teachers build up knowledge of pupils as they go along. What my study does is to provide insight into one area of knowledge about pupils which it is important to acquire.

The case studies I wrote point to another aspect of considering the beliefs of pupils. These case studies are not unlike the profiles which teachers are now having to write about pupils. I hope that my case studies indicate ways in which such profiling can be useful to the teacher who writes them as much as to those who will read them.

9.3 Suggestions for further work

My first suggestion arises from my earlier discussion of personal control combined with a determination to succeed in all subjects and a belief that you come to like a subject once you are good at it. The data on which my discussion was based came from background material from the three interviews and was demonstrated in the way the pupils behaved in the problem-solving sessions. Unfortunately, other than to ask about choosing mathematics if it was an optional subject, I asked no questions which could lead to direct information on
the matter. It is something which requires further study.

I have four more suggestions for further inquiry which arise from my work and I will deal with them in the order in which I have previously discussed them.

My first suggestion concerns whether or not some pupils, particularly those in higher sets, adopt the belief that one ought to try to be objective. I suggested that such a belief could be useful for the learning of school mathematics as it is presently taught but I would add that, as the teaching of mathematics becomes more problem centered, it could become counter productive. Objectivity, in this sense, involves trying to find meaning in that which is given. The creativity which is needed for problem-solving involves looking into oneself to provide meaning.

I suggested that it may be necessary to look separately at attitudes towards routine work and attitudes towards problem-solving. Work in this area is my second suggestion. I believe it might well be that differences in beliefs about whether it is necessary to understand what one is doing at each stage of a process are also involved here. In routine work it is possible to learn how to perform an algorithmic process and only later to understand the concepts which lie behind it. Perhaps a belief that such an approach is acceptable plays a part in the success which some pupils have with routine work.

My third suggestion has to do with the beliefs involved when pupils are obviously happy to assume that a problem is solved when it is clear to the observer that there is more work to be done. In particular it would be useful to know if there is any involvement of the belief that an approximate answer is, frequently, sufficient for school mathematics in the same way that it would be sufficient in everyday life.

Finally, it would help if we knew of any particular groups of beliefs which play a noticeable part in success or
failure at school mathematics. I have argued that, for each individual pupil, it is a constellation of beliefs which count but I also noted that, for some of the groups which I created, there was greater variation between the top and the bottom sets than there was for the other groups.

9.4 The need for changes in belief at the national level

At the beginning of this chapter, and in reference to myself, I remarked that old beliefs die hard. Almost daily, I am reminded that this is particularly the case with mathematics. Many adults, particularly those who are in positions of authority or who have the ability to influence the behaviour of others, are suspicious of any changes in the approach to the teaching of mathematics. Their suspicions are even shared by a considerable number of mathematics teachers.

Their concerns appear to involve a number of specific beliefs. One is that anything that was learned in the past in mathematics is useful and should be retained. Along with this goes the belief that anything which has been introduced into the mathematics curriculum in recent years is frivolous and unnecessary. Another is that mathematics is a body of knowledge to be handed down from teacher to pupil. The corollary to this is that the pupils' role is the non-creative one of acquiring large numbers of facts and learning how to perform many different algorithms.

I came across one rather worrisome result of the first two of these beliefs about two years ago. A national examination board had set up a series of examinations for less able pupils. The syllabuses had been arrived at in consultation with employers in order that the material covered by the pupils should be in line with the needs of industry. The syllabus in mathematics looked, to me, as if it
had been based on the arithmetic part of the eleven plus examinations of bygone years. On enquiry I was told that this syllabus was exactly what the employers required and that there was evidence to show that they were well pleased with the results because now pupils were coming into employment armed with suitable mathematical knowledge. When I pressed further and asked if there had been any research to discover whether or not the workers actually used this particular material I met with bewildered silence. I assume that behind that silence lay the belief that employers actually know what is needed rather than that they believe that they know. I remain unconvinced.

I feel sure that the belief that learning mathematics merely involves the acquisition of facts and the learning of algorithms informed a comment recently made by the Secretary of State for Education. Smiling with clear delight at his justification for traditional methods, he remarked that children enjoy learning things off by heart.

The point which I wish to make is that it is not sufficient to concern ourselves with the beliefs of pupils. We also need to consider ways in which to influence the beliefs of society at large. Parents have an influence on the beliefs of their children and those with authority and power have steadily growing influence on what may be taught and the methods which may be used. To attempt to influence pupils' beliefs without considering the adults is to court failure.
Many people have difficulty in learning mathematics - a problem in which I became interested whilst teaching the subject at the Littlehampton School. I am now at Surrey University studying the ways in which young people think about mathematics and attempting to discover attitudes and approaches which either help or hinder their mathematical development.

In the coming months I would like to spend some time with each member of your child's Tutor Group (1R1) as well as talk to them in groups of three or four. I would also like to talk to as many parents as possible because I feel sure that this would add to my understanding of the subject.

I must stress that I would not be testing your child's ability in mathematics so there would be no cause for nervousness or embarrassment. At all times I would make clear just what we are doing and why and all my findings will be kept strictly in confidence.

Discussing a problem often helps to reduce it and so it is possible that your child's mathematics may be helped by taking part.

I hope that you will help me by allowing your child to take part in this study. If you agree please sign the form at the end of the letter and return it as soon as possible in the enclosed stamped, addressed envelope.

I hope you will also agree to meet me yourselves. If you say yes I will contact you personally to arrange a time and place which is convenient to you.

Yours sincerely

Patricia Lucock (Mrs)
ART

MATHS

SCIENCE

NEEDLEWORK

APENDIX B1(3)
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APPENDIX C1(2)
\[
\begin{array}{cccccc}
(a) & 4.2 & (b) & 2.98 & (c) & 6.32 \\
3.6 & 3.75 & 4.71 & 4.96 \\
+ & 5.8 & + & 4.62 & + & 5.39 \\
(\text{e}) & 5.12 & (f) & 5.64 & (g) & 4.08 \\
-3.01 & -4.83 & -2.193 & -1.887 \\
\end{array}
\]

\[
\begin{array}{cccc}
(a) & \frac{1}{4} & (b) & \frac{1}{2} \\
(c) & \frac{3}{10} & (d) & \frac{42}{100} \\
(e) & \frac{1}{8} & (f) & \frac{2}{5} \\
(g) & \frac{9}{20} & (h) & \frac{1}{3} \\
\end{array}
\]

\[
\begin{align*}
(a) & \quad 6.7 + 4.52 + 5.3 + 2.64 \\
(c) & \quad 3.14 \times 7 \\
(b) & \quad 3.004 - 2.06 \\
(e) & \quad 6.84 \times 1.2 \\
\end{align*}
\]

\[
\begin{align*}
(a) & \quad 0.3 \\
(b) & \quad 0.6 \\
(c) & \quad 0.8 \\
(d) & \quad 0.75 \\
(e) & \quad 0.56 \\
(f) & \quad 0.32 \\
(g) & \quad 0.375 \\
(h) & \quad 0.5 \\
(i) & \quad 0.96 \\
(j) & \quad 0.875 \\
\end{align*}
\]

\[
\begin{align*}
(a) & \quad 0.04 \\
(b) & \quad 0.039 \\
(c) & \quad 0.042 \\
& \quad 0.42 \\
& \quad 0.419 \\
& \quad 0.1 \\
& \quad 1.001 \\
& \quad 0.01 \\
& \quad 0.001 \\
& \quad 10.01 \\
& \quad 1.01 \\
(c) & \quad 0.375 \\
& \quad 0.4 \\
& \quad 0.3075 \\
& \quad 0.3507 \\
& \quad 0.3507 \\
& \quad 0.3507 \\
& \quad 3.705 \\
\end{align*}
\]
\begin{align*}
(a) \quad & \frac{2}{5} + \frac{1}{2} = \quad (b) \quad \frac{7}{13} + \frac{3}{10} = \\
(i) \quad & \frac{3}{4} - \frac{1}{6} = \quad (j) \quad \frac{5}{7} - \frac{3}{5} = \\
(c) \quad & \frac{3}{10} \times \frac{5}{6} \quad (d) \quad \frac{5}{8} \times \frac{1}{10} \\
(d) \quad & \frac{6}{5} \div \frac{3}{5} \quad (o) \quad \frac{3}{5} \div \frac{3}{5} \\
(g) \quad & \frac{1}{3} + \frac{1}{4} = \quad (h) \quad \frac{2}{9} + \frac{2}{5} = \\
(c) \quad & \frac{1}{2} - \frac{2}{5} \quad (d) \quad \frac{1}{4} - \frac{1}{8} \\
(g) \quad & \frac{7}{8} \times \frac{3}{8} \quad (h) \quad 6 \times \frac{5}{6} \\
(d) \quad & \frac{1}{5} \div 6 \quad (e) \quad \frac{1}{5} \div 12
\end{align*}
\[ 2 \frac{1}{3} \times 3 \frac{1}{4} = 3 \frac{2}{3} \]

**Multiplication and Division**

\[ \frac{7}{3} \times \frac{22}{7} = \frac{11}{3} \]

**Make "top heavy"**

\[ \frac{7}{3} \times \frac{22}{7} \times \frac{3}{11} \]

**Turn divisor upside down and Multiply ...**

\[ \frac{7}{3} \times \frac{22}{7} \times \frac{3}{11} = \frac{2}{1} \]

**Cancel or Reduce**

APPENDIX C1(7)

250
The following figures have been split up into rectangles. Find their areas.

(a)

(b)

(c) Fig. 14 (d)
These wedges of cheese have slightly different angle sizes. Give them in order from the smallest angle to the largest.

(a)  (b)  (c)  (d)

Fig. 13

A man is fitting lino at this corner of a floor.

Wall

Wall

Which of these pieces would fit the corner?

(a)  (b)  (c)  (d)

(a)  (b)  (c)  (d)  (e)
Through what angle do you turn in going,

(a) from south clockwise to west;
(b) from north-west clockwise to north-east;
(c) from north clockwise to south-east;
(d) from north-west anticlockwise to south;
(e) from north-east anticlockwise to south-east?

A reflex angle is an angle greater than two right-angles but less than four right-angles (see Figure 18).

An acute angle is an angle less than a right-angle.

Fig. 16

An obtuse angle is an angle greater than one right-angle but less than two right-angles.
1 List the members of the following sets:
   (a) \{the colours of a set of traffic lights\};
   (b) \{the subjects on your timetable\};
   (c) \{the days of the week\};
   (d) \{the letters of your surname\};
   (e) \{the five continents\}.

2 Give a description which defines the following sets:
   (a) \{f, p\};
   (b) \{hearts, clubs, diamonds, spades\};
   (c) \{a, e, i, o, u\};
   (d) \{sight, hearing, smell, touch, taste\};
   (e) \{September, April, June, November\}.

3 Are the following statements true or false?
   (a) A square is a member of the set of polygons.
   (b) The Earth is a member of the set of planets.
   (c) An oak is a member of the set of flowers.
   (d) Tennis is a member of the set of sports.
   (e) Manchester is a member of the set of cities of England.
Any dot inside this boundary represents a member of the set A.

All dots enclosed either by the A boundary or by the B boundary (or both) represent objects belonging to the union of A and B.

Dots inside this boundary represent objects that belong to A and to B.

APPENDIX C1(13)
APPENDIX C1(14)

257
APPENDIX C1(15)
APPENDIX C1(16)
APPENDIX C1(17)
261
+ 432
-----
 752

600
-359
-----
 241

46
× 34
-----
184
1380
1564

APPENDIX C2(1)
\[
\begin{align*}
15 \) & 3450 \\
30 & 30 \\
45 & 45 \\
\end{align*}
\]

\[
\begin{align*}
3.4 & \quad 6.2 \\
2.03 & \quad -3.08 \\
+4 & \quad 3.12 \\
9.43 & \quad 0.6 \\
\end{align*}
\]

3.46 to 1 decimal place is 3.5
3.46 to 1 significant figure is 3
\[
\frac{1}{3} + \frac{3}{5} = \frac{5}{15} + \frac{9}{15} = \frac{14}{15}
\]

\[
\frac{1}{2} - \frac{2}{9} = \frac{9}{18} - \frac{4}{18} = \frac{5}{18}
\]

\[
\frac{\frac{2}{3}}{\frac{1}{10}} \times \frac{\frac{3}{5}}{} = \frac{2}{3} \times \frac{9}{10} = \frac{3}{5}
\]

\[
\frac{\frac{4}{5}}{\frac{8}{15}} = \frac{4}{5} \div \frac{8}{15} = \frac{4}{5} \times \frac{15}{8} = \frac{3}{2} = 1\frac{1}{2}
\]

\[-3 + 5 = 2 \]

\[-8 - 5 = -3 \]

\[-3 \times 4 = -12 \]

\[-3 \times 4 = 12 \]
\begin{equation}
1011_2 = 11_{10}
\end{equation}
\begin{equation}
341_5 = 96_{10}
\end{equation}
APPENDIX C2(5)

A = \{1, 2, 3, 5\}
B = \{1, 4, 5, 7, 9\}

A \cap B = \{1, 5\}
A \cup B = \{1, 2, 3, 4, 5, 7, 9\}

P
\begin{bmatrix}
0 & 1 & 0 & 1 \\
1 & 2 & 1 & 0 \\
0 & 1 & 0 & 1 \\
1 & 0 & 1 & 2
\end{bmatrix}

\begin{tikzpicture}
\node (P) at (0,0) {P};
\node (Q) at (1,1) {Q};
\node (R) at (2,2) {R};
\node (S) at (0,1) {S};
\draw (P) -- (Q) -- (R) -- (S) -- (P);
\end{tikzpicture}
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Mean of sum of scores for the three constructs for each pupil

APPENDIX D TABLE 1

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Degree of correlation between the three constructs for each pupil (maths topics)

APPENDIX D  TABLE 2B

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Pupils above and below mid-point of range for the three constructs

APPENDIX D TABLE 4
### Hypothesised grouping for categories

**APPENDIX D**  **TABLE 5**

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<th>Pupil Number and Set</th>
<th>Can work with noise and mess</th>
<th>Teacher needs not be studied</th>
<th>Teacher's personality does not matter</th>
<th>Understanding of own efforts</th>
<th>Prefers problems</th>
<th>Prefers diagrams help</th>
<th>Cannot work with noise and mess</th>
<th>Teacher needs to be strict</th>
<th>Parents do not help</th>
<th>Parents do not matter</th>
<th>Teacher's personality is not important</th>
<th>Learning depends on intellectual characteristics</th>
<th>Prefers sums</th>
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<td>4) My parents help me with my homework.</td>
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<td>5) The personality of the teacher does not matter.</td>
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<td>6) Understanding what you are doing in mathematics is more important than being able to do the work.</td>
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<td>7) Learning in mathematics depends on how willing you are prepared to work.</td>
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<td>8) I would rather do problems than sums.</td>
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<td>9) Diagrams can help when you are doing mathematics.</td>
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Categories, with contribution numbers for top and bottom sets

APPENDIX D TABLE 6
### APPENDIX D: TABLE 7

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<th>Can work with noise and mess about</th>
<th>Keeps trying</th>
<th>Teacher needs to be strict</th>
<th>Parents do help</th>
<th>Teacher's personality does not matter</th>
<th>Understanding is not important</th>
<th>Learning depends on your own efforts</th>
<th>Prefers problems</th>
<th>Diagrams help</th>
<th>Cannot work with noise and mess about</th>
<th>Gives up</th>
<th>Teacher need not be so strict</th>
<th>Parents do not help</th>
<th>Teacher's personality does matter</th>
<th>Understanding matters</th>
<th>Learning depends on inherited characteristics</th>
<th>Prefers sums</th>
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**MEAN OF MEANS**

**ARITHMETIC**

| Mean of scores across the three constructs plus
| correlation for each pair of constructs |

**APPENDIX D TABLE 8**
Mrs. Chalmers is buying Christmas presents for her seven children to give to one another. Each child gives a present to each of the others. How many presents must she buy?
My age this year is a multiple of seven and next year it will be a multiple of five. If I am not yet fifty but I am older than thirty, how old am I?
If each of four people shakes hands once with each of the other three, how many handshakes will there be? How many if there are five people?

Is there an easy way of working out the number of handshakes for any number of people?
This solid cube is made up of 125 unit cubes.

How many unit cubes have three faces exposed?
Two faces exposed?
One face exposed?

To help you, one of each type of exposed face has been shaded in.
5. The problem is to arrange four triangular tiles to make a large triangle like this.

However, wherever two triangles touch each other along an edge, the numbers on those two edges have to be added together to make a "touch total." The three touch totals made in the large triangle must all be the same.

For example, given these four tiles (and that Touch Total = 9)

We can make

Use each of the sets of tiles and try to make the large triangle for each set which shows the correct Touch Total. Each set has its own letter.

SET A - TOUCH TOTAL = 4
SET B - TOUCH TOTAL = 7
SET C - TOUCH TOTAL = 9
SET D - TOUCH TOTAL = 11
SET E - TOUCH TOTAL = 13
SET F - FIND OUT WHAT THE TOUCH TOTAL IS

APPENDIX E(5A)

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APPENDIX E(58)
Mrs. Brown breeds dogs. At present she has eleven of which seven are spaniels and eight are puppies. How many spaniel puppies is it possible for her to have?
A boy has two bags, two red marbles, and two green marbles. He places one red marble and one green marble in each bag.

If he now chooses one bag at random and then draws out of that bag one marble at random, is it equally likely to be red or green?

If he repeats the experiment fifty times, about how many times do you think he is likely to draw a green marble?
Suppose now the bag places both red marbles and one green marble in one bag and the other green marble in the other bag and repeats the actions just described: are a red and a green marble equally likely to be drawn now?

If he repeats the experiment fifty times, about how many times do you think he is likely to draw a green marble?
The bottom layer of the pyramid contains $5 \times 5 = 25$ unit cubes. The next layer $4 \times 4$, the next $3 \times 3$, and so on.

How many cubes are hidden from the outside?

How many cubes have only one face, two faces, three faces, four faces, five faces visible?
I bought two chocolate bars and three packets of fruit gums for 76p. My sister bought three chocolate bars and one packet of fruit gums for 65p.

Now my father says he will pay for the chocolate bars and my mother says she will pay for the fruit gums, but neither my sister nor I can remember the prices.

See if you can work out the price of a chocolate bar and the price of a packet of fruit gums.
NOTE:- ? Indicates an answer which was changed.

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Question 1 - Christmas Presents

APPENDIX E TABLE 1

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GROUP 1:— BELIEFS ABOUT THE NATURE OF MATHEMATICS AND HOW TO GO ABOUT IT.

QUESTION 1) What method do you use to revise in maths?
RESPONSES:-
57) For maths revision I learn how to do the topic and work through some examples.
56) For maths revision I read through and do some examples.
82, 81, 77) For maths revision I read through and try to learn it but I don't do any examples. (Two do revision only in class.)

QUESTION 2) Have you always used this method?
RESPONSES:-
49) My revision methods have changed. (Method demonstrates that the change is for the better.)
83) I've always used the same method for revision. (Indicating a method likely to be unhelpful.)
78) I have always used the same method of revision in maths. (Appear to be quite useful methods.)

QUESTION 3) Do you use the same revision methods in other subjects?
RESPONSES:-
76) My revision methods are different for maths to other subjects. In other subjects I don't do working out.
79) I revise for other subjects but not for maths.
139) I use the same revision methods for all subjects.

QUESTION 4) Do you ever estimate a mathematical answer?
RESPONSES:-
16) I estimate in maths. (Examples given.)
124) I estimate in maths. But couldn't say when. (Suggesting a feeling that it's a good thing to do but not knowing how to use it.)
I never estimate in maths.

QUESTION 5) Would you copy in maths?

RESPONSES:-

50) I would copy but only to work through and gain understanding.

125) I would not copy in maths.

89) I would copy to get out of trouble or just to keep up with others.

QUESTION 6) Do you ever guess the answer in maths?

RESPONSES:-

122) I would make a calculated guess in maths.

97) I would guess the answer in maths. (Pure guess)

106) I don’t guess. If I don’t know the answer I just leave it empty.

QUESTION 7) What pleases you the most, getting the answer right or finding out a way of working out the problem?

[NEUTRAL]

RESPONSES:-

62) Both please me as much as each other.

7,8,160) It pleases me to have a way of working it out.

161) It pleases me most to get the answer right.

QUESTION 8) Now that many people have calculators do you think it is necessary to learn things like the four rules, multiplication tables, decimals, percentages and fractions or would it be enough just to know how to work them out on a calculator?

RESPONSES:-

65) You need to learn the method as well as how to do it on the calculator because its important to understand.

102) You need only learn on the calculator.

157) You need to learn the method as well. You may not always have your calculator with you.

QUESTION 9) Can you see a clear connection between the work you do one year in maths and the work in other years?
[NEUTRAL]

RESPONSES:-

58) Yes. Its the same as last year but at a higher level.
104) Its exactly the same as last year.
105,158) I can see no connection.

QUESTION 10) Does it surprise you if you can't understand something fairly quickly in maths?

RESPONSES:-

2) I'm not surprised if I don't understand quickly in maths. It always takes time.
118) I'm not surprised if I don't understand quickly in maths. Its always difficult for me.
134) Yes it does surprise me if I don't understand quickly.

QUESTION 11) In your maths lessons who do you feel you are doing the work for? [NEUTRAL]

RESPONSES:-

84) I do it for myself and for the teacher when it is something I don't like.
85) Just for the teacher.
10,19) For myself and for the teacher to show appreciation.
12) For myself.
20) For myself, my parents and my teacher.
31) For myself and my parents.

QUESTION 12) Would you prefer to be set or not to be set for maths?

RESPONSES:-

28, 29, 121) I prefer to be set so as not to be held back.
110) I prefer to be set so that I won't fall behind or I won't copy.
8,109) I prefer not to be set because you can help each other. (Three added that it could be harmful to lower set people.)
133) I prefer to be set and then I'm with people of my own ability.
QUESTION 13) Do you think that maths needs to be taught in a different way to other subjects?
RESPONSES:-
162,163) Maths needs to be taught more thoroughly and with more explanation than other subjects.
60,61) Maths doesn't need to be taught differently to other subjects. (Two added that pupils had to work harder.)

QUESTION 14) Someone said, "I like maths because it's a challenge. I find it different to other lessons because you have to do more working out yourself." What do you think about that remark?
RESPONSES:-
155) Maths is a challenge and there is more working out.
103) Maths is more working out but I don't like the challenge of it.
63) Maths is no different to other subjects in this respect.
64) Maths is a challenge. There's more working out and I like it.

QUESTION 15) Someone else said, "I think everyone can be good at maths." Do you agree with them? (If the answer was "No" then this would be followed by "Would you agree with them if they were talking about the maths you do in everyday life?")
RESPONSES:-
6,108) Everyone can be good at maths if they work hard.
119,120) Not everybody can be good at maths. (All but two saying, "but they can be good at everyday maths").

QUESTION 16) Another person said, "I like maths because once you've learned the rules you can put them into practice." What do you think about that remark?
RESPONSES:-
159) I agree. Maths is rule based.
59,156) I disagree or I don't understand what that means.

QUESTION 17) Would having a qualification in maths help you in getting a job?
RESPONSES:-
45) A maths qualification would help me. I need one for the job I want to do.
151) I don't know if a maths qualification would help me to get a job.
44) A maths qualification would help me because it would impress employers.
95) A maths qualification would not help me in getting a job.

QUESTION 18) Would being able to do maths help you in getting a job?
RESPONSES:-
42) Being able to do maths would help me. I need it for the job I want to do.
43) Being able to do maths would help me because it is needed for any job.
90) Being able to do maths would not help me in getting a job.

QUESTION 19) When it comes down to doing your working out in maths are there differences between what is needed in everyday life and in school?
RESPONSES:-
27) I would use school-taught methods to do everyday maths.
154) I'd do maths at home in a different way to how it is taught at school.

GROUP 2:- WHAT INDIVIDUAL PUPILS GET FROM LEARNING MATHEMATICS AND THEIR BELIEFS ABOUT OTHER PEOPLE AND MATHEMATICS.

QUESTION 20) Do you think you get better results in maths homework or in maths exams or do you do as well in both?
RESPONSES:-
92,93,144) I get better results in homework than in exams
because there is less pressure.

142) I don't know if I do as well in homework as exams.

48) My results are the same in exams or homework.

143) I get better results in exams because I revise for them.

QUESTION 21) Do you think you get better results in maths homework, maths lessons or maths exams?

RESPONSES:-

47) I achieve as well in class, at homework or in exams.

91) I get better results at home. There is pressure or distraction in class and exams.

141,145) In class because it's easier to work there and there is someone to help you.

46) Better results from exams because I prepare for them.

QUESTION 22) Do you do better in other subjects than you do in maths? [NEUTRAL]

RESPONSES:-

14,132) I am about the same in all subjects. (One said better at maths.)

130) Yes. I'm better at languages.

73,74,131) Yes. In all other subjects/In humanities and sciences/In all except languages.

QUESTION 23) What sort of person do you think gets most out of learning maths? [NEUTRAL]

RESPONSES:-

51,52) The people who get the most out of maths are those who work at it and those who are not very good at it.

99,100,101) Those who enjoy it/are good at it/want a career from it.

153) I don't know.

QUESTION 24) What sort of person do you think most enjoys learning maths?

RESPONSES:-

98) The person who most enjoys maths is the one who is good at it.
QUESTION 25) What do you get out of your maths lessons?

[NEUTRAL]

RESPONSES:-

5, 39, 40) Achievement and something for the future.
147) I don't know what I get out of it.
96) I get very little or nothing out of my maths lessons.
146) It depends on the lesson. Sometimes nothing.

GROUP 3:- FEELINGS ABOUT MATHEMATICS.

QUESTION 26) Do you find any maths topics fun to do?

[NEUTRAL]

RESPONSES:-

135) No.
136) Yes. (A great variety of explanations.)

QUESTION 27) Could you imagine doing maths just for pleasure?

[NEUTRAL]

RESPONSES:-

35, 37,) Yes.
80) I wouldn't do maths for any reason.
150) No. I would only do it because I need it/ because it's important.

QUESTION 28) If maths lessons were optional would you choose to do them?

RESPONSES:-

33, 34) I would still do maths if it was optional because I need it and I quite like it as well.
148, 149) I would do maths if it was optional although I don't like it. Reasons:- I need it for the job I want to do or it is important for any job.
94) No. I would not.
QUESTION 29) Do you like cooperating with other people in your maths lessons?

RESPONSES:

1,26) I like to cooperate because you can help each other.
86,87) I sometimes don't like to cooperate with others. One said "Not unless I know I can trust them." The other one said, "Because I probably wouldn't work."
17,126) I like to cooperate with others for what I can get out of it.
127) I like to cooperate because it's fun.

QUESTION 30) Do you like competing with other people in your maths lessons?

RESPONSES:

4) I don't like to compete because I prefer to do my own thing.
68) I don't like to compete with others because I'm no good at maths.
128) No, but I don't know why.
3,116) Yes. I like to outdo others.

QUESTION 31) Do you find it easy to answer questions in front of the class in maths?

RESPONSES:

115,117) Only when I feel I won't be laughed at if I'm wrong.
69,70,71) No. Because I'm shy/ Because I get embarrassed.
11,30) Yes because I don't care what others think/ But I don't know why.

GROUP 4:- GENERAL BELIEFS NOT NECESSARILY TO DO WITH MATHEMATICS.

QUESTION 32) Why do you think we have exams?

RESPONSES:

187) We have exams to see how much we have learned during the
year.

184,185,186) We have exams for one of following reasons:- So we can be put into the proper set or as practice for external exams.

183) I don't know why we have exams.

QUESTION 33) Do you think exams are a good idea?
RESPONSES:-
194,197) I don't approve of exams. Continuous assessment is better.
193,195) I approve of exams. (As opposed to continuous assessment)
196) I don't know if they are a good idea.

QUESTION 34) Is continuous assessment a good idea? [NEUTRAL]
RESPONSES:-
176,177,178) Yes it is a good idea.
175,179,180) No it is not a good idea.

QUESTIONS 35) Are teachers failing in their jobs if they don't make sure that you are working hard and really do your best to learn? [NEUTRAL]
RESPONSES:-
166,) No. Its up to the pupil.
198) No. The teacher doesn't have enough time.
172,173,174) Yes because that is the teacher's job.

QUESTION 36) What were your reasons for choosing your options?
RESPONSES:-
200) I chose my options from a mixture of choice and need.
167) I chose my options only for liking.
201) I chose my options only because I need them for a job.

QUESTION 37) What do you get out of going to school? [NEUTRAL]
RESPONSES:-
185,192) Learning first but the social side too.
169) There is no main thing I get from school. I would rather
be at home.
170,171) The main thing is the social side/ An antidote to boredom.

QUESTIONS 38) Do you ever do puzzles at home?
RESPONSES:
188,190) I do crossword puzzles. (Some also do other types of puzzles.)
189) I don't do any sort of puzzles.
191) I do word and/or number searches.

QUESTION 39) Are you a fairly patient sort of person?
RESPONSES:
181) No but I don't give up easily in maths. I get frustrated and stop but then I come back to it. I am the same with other subjects.
168,182) I'm not patient so I just give up if I can't do the work.
184) I am patient and I don't give up easily.

GROUP 5:- POSSIBLE SOURCES, INTERNAL AND EXTERNAL, OF PRESSURE TO WORK HARD (OR NOT TO) IN MATHEMATICS.

QUESTION 40) Are your parents concerned about how well you do in maths?
RESPONSES:
23,114) My parents are concerned about how well I do in maths because its an important subject.
22) My parents are concerned about how well I do in all subjects.
87,88) My parents are not really concerned about how well I do in maths.

QUESTION 41) Are you concerned about what your friends think about how well you do in maths?
RESPONSES:
129) I'm not concerned about what my friends think about how well I'm doing in maths. It's what I know myself that matters.
129a) I'm not concerned about what my friends think about how well I'm doing in maths. I can only do my best.
18) I'm not concerned about what my friends think about how well I'm doing in maths. They don't want me to work. I might want to.
112) I am concerned about what my friends think because I don't want to lose face.

QUESTION 42) Are you concerned about what your parents think about how well you do in maths? [NEUTRAL]
RESPONSES:
24,32) Yes, I'm concerned because I want their approval/Maths is an important subject.
107) I'm not concerned about what my parents think. It's up to me.

QUESTION 43) Are you concerned about what your teacher thinks about how well you do in maths?
RESPONSES:
13) I'm concerned about what my teacher thinks of my progress in maths because I try to demonstrate that I am making progress.
75) I'm not concerned about what my teacher thinks about how well I'm doing in maths. I can only do my best.
21,113) I am concerned about what my teacher thinks because I want her reassurance/ I need her help.

QUESTION 44) Are you yourself concerned about how well you do in maths? [NEUTRAL]
RESPONSES:
15) I'm concerned about how well I do in all subjects including maths.
25,41,111) I'm concerned about how well I do in maths because it's an important subject/ I need it for a job/Because I'm not very good at it.
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Discriminating in favour of top sets

Beliefs about the nature of mathematics
and how to go about learning it

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**Discriminating in favour of top sets**

Beliefs about the nature of mathematics
and how to go about learning it

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**Discriminating in favour of bottom sets**

Beliefs about the nature of mathematics and how to go about learning it

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Discriminating in favour of bottom sets

Beliefs about the nature of mathematics
and how to go about learning it

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Beliefs about the nature of mathematics
and how to go about learning it

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Beliefs about the nature of mathematics and how to go about learning it

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What individuals get from learning mathematics and believe about other people and mathematics

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**Feelings about mathematics**

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Feelings about mathematics

APPENDIX F2  TABLE 5Y
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|----------|----------|----|----|----|----|----|----|----|----|----------|----|----|----|----|----|----|----|----|----------|----|----|----|----|----|----|----|----|----------|----|----|----|----|----|----|----|----|----------|----|----|----|----|----|----|----|----|
|          |          | 194 | 187 | 197 | 200 | 190 | 181 | 184 | 193 | 167 | 165 | 196 | 198 | 176 | 175 | 169 | 172 | 165 | 170 | 183 | 196 | 177 | 179 | 198 | 173 | 192 | 171 | 169 | 191 | 164 | 174 |
| 10       |          | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
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| 7        |          |     |     |     | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| 11       |          |     |     |     |     | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| 14       |          |     |     |     |     |     | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| 27       |          |     |     |     |     |     |     | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| 13       |          |     |     |     |     |     |     |     | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| 23       |          |     |     |     |     |     |     |     |     | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
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General beliefs not necessarily to do with mathematics

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Discriminating in favour of bottom sets

Neutral

General beliefs not necessarily to do with mathematics

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**Possible sources, internal and external, of pressure to work hard (or not) in mathematics**

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**APPENDIX F3  TABLE IY**

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- **Lack of understanding of how to go about things/unwillingness to make effort**
- **Lack of belief in own ability**
- **Lack of intrinsic drive to do well in maths**
- **Extrinsic reasons for doing maths**
- **Having priorities/beliefs which clash with working at maths**
- **School maths approach is not for everyday life**
REFERENCES

Cockcroft Committee. 'Mathematics Counts'. 1982. HMSO.
Erlwanger, S.H. 'Benny's Concept of Rules and Answers in IPI
McLeod, D.B. 'Affective Influences on Mathematical Problem


