unity" but points out that it is sometimes difficult to distinguish this from validity and in this section only validity and reliability will be discussed. There are many difficulties in establishing validity and reliability for the instruments designed in section 5.4. because behavioural research by its very nature must invent ir lirect means to measure psychological and educational properties. These means are often so indirect that the validity of the measurement and its products is doubtful (Kerlinger, 1986, P.416). However the problem must be faced because as Katz (1953) shows an important characteristic of field studies is the degree of measurement they represent and this can vary from

> "the extreme of the interpretative anthropological description" to "an investigation employing standardized quantification of data collection in the form of observational scales for recording behaviour and attitude scales for the measurement of beliefs and feelings" (P.59).

It is a basic scientific assumption that when conditions are constant the results must be the same (Peak 1953, P.292) but the field of the present research is very far from the stage of being this well developed scientifically. The instruments outlined in this chapter have been designed specifically for this research because no suitable instruments were available in the literature. Apart from the questionnaires, the qualitative data were gathered by observation and interviews and this makes it:

> difficult to confirm conclusions by other investigators because of the difficulty of duplicating the exact procedures on which the conclusions were based (Katz 1953, P.62).

Kerlinger (1986) speaks of the "molar-molecular problem" in any measurement procedure in the social sciences by which he means taking large behavioural units of observation as opposed to taking smaller segments of behaviour as units of observation (P.490). The smaller the units studied the greater is the precision and reliability but it is only by using broad areas of study that a large degree of validity can be achieved (*ibid*). The usual way out of this dilemma is to compromise but some authors take the more drastic step and reject the whole discussion as being meaningless in the kind of research which is undertaken here. For example Cohen and Manion (1980) quote Kitwood's unpublished doctoral thesis (1979) in which it is claimed that the use of interview as a research tool generates a conflict between traditional concepts of validity and reliability and in some research these become "redundant notions" (Cohen & Manion 1980, P.253). The present research cannot accept this extreme view and both validity and reliability are held to be important issues. In so far as possible the usual statistical procedures for these criteria were used as described below. An extra check viz. triangulation for both validity and reliability was also used where appropriate.

5.7.1. Validity

By validity is meant truthfulness of the instrument in measuring what it purports to measure (according to Kerlinger 1986, P.417), this is the most commonly accepted definition. There is is however no one validity - a test or scale .. valid for the scientific or practical purpose of its user and in a different situation it might or might not be valid (ibid). Several kinds of validity are presented by different writers on research methodology e.g. Cohen & Manion speak about external and internal validity (1980, P.164) while Kerlinger says the most important classification of types of validity is into: content validity, criterion-related validity and construct validity (1986, P.417); Peak (1953, P.283) discusses three kinds of validity as: (i) face validity, (ii) prediction to a criterion validity, and (iii) testing predictions from theory. According to Siann & Ugwuegbu (1980) the biggest threat to validity in a cross cultural setting is personal bias of the researcher (P.233) and Cohen & Manion (1980) elaborate on the sources of bias in the interview situation which they list as: the characteristics of the interviewer, those of the respondent and the substantive content of the questions (P.252).

In this research into success and failure in mathematics among Tswana students the following methods were adopted in order to control validity:

(a) Participant observation - the researcher immersed himself in the situation. This was made easier because the researcher has lived in Phokeng for 11 years during which time he has taught mathematics in Bafokeng High School, has participated in adult education programmes in the village, has helped organise and conduct in-service courses in mathematics for standard 7 teachers in the Bafokeng region, is a member of the high school teachers commitee to promote better mathematics teaching and learning, has had close contact with several Tswana teachers doing further studies at Teacher College or University, and has a moderate knowledge of Setswana. Some authors say participant observation is not really possible but Cole <u>et al</u> (1971) reject this standpoint.

(b) Personal bias on the part of the researcher is almost impossible to control but by stating one's personal position the researcher can at least become aware of possible bias. This researcher recognises that he likes people and can easily "over-encourage" some students especially if they respond in a friendly manner; he does not like reserved shy people; he can easily establish rapport with students in the interview situation but expects students to take him seriously and gets annoyed if they show signs of boredom or fidget; the researcher likes behaviour which shows Tswana students to be similar in manner to what is regarded as "Irish"; he thinks the Tswana students can be very successful in mathematics if they are taught in a way consistent with their own culture.

(c) The third method used is to base the meas··ing instruments as far as possible on the work o· ·ther researchers. This method was employed by maki.. . .e of the work done by Witkin, Husèn, McClelland, Skemp and Hart among others.

By validity in the present research is meant that each instrument measures what it is stated to measure (Guilford 1950 P.512). In the present research validity was established for each instrument separately and the particular aspect of validity measured is given in the appropriate section.

5.7.2. Reliability

Reliability has been variously defined as: stability, dependability and predictability; or as: consistency of scores produced by an instrument over time; or as: the accuracy or precision of a measuring instrument (Kerlinger 1986, P.405). An unreliable measurement therefore is overloaded with error and while reliability is a necessary condition for scientific research it is not of itself sufficient to establish the value of reseach results. It is a fairly simple matter to establish reliability for the quantitative instruments designed for this research by:

(a) using the split halves reliability coefficient described by Ary et al (1985, P.231). This is done by dividing the items into odd and even numbered ones and test the correlation between them.

(b) Building into the questionnaires a reliability control by repeating one question in an alternative form. Those respondents who fail this control will be counted and a consistency of response percentage calculated.

(c) Assign individual responses to a category by two or more independent scorers.

The qualitative data on the other hand present more serious difficulties and in this research the triangulation technique of gathering data from different sources and cross checking to arrive at a reliable result was used as has been described in the pilot study in section 4.5.2. The other technique is that referred to as "content analysis" as described in the next section and it was used hand in hand with triangulation to check both reliability as well as validity.

5.7.3 Summary

The controls on validity and reliability used are set out in Table 5.4 The manner in which each research instrument was controlled is also indicated.

Table 5.4 Summary of research controls used for each instrument

Instrument	Validity	Reliability
1) attitudes questionnaire	based on Husén(1967)	split halves test triangulation repeated questions
2) cultural beliefs	based on McClelland(1975)	do
3) socio-economic status	based on Kiely(1983)	do
4 s lf image para- graph	based on Minkowich(1982)	two scorers assign to categories content analysis
5) interviews	participant observation personal knowledge based on Hart(1981)	2 scorers for categories focus on process rather than answer content analysis
6) observations	participant observer	triangulation content analysis
7) non-formal interviews	participant observer	triangulation content analysis
8) small scale tests	purpose of these was to deepen our understanding and it was largely exploratory and no claims are made regarding the reliability or validity of these.	

5.8 Analysis of data

Two major procedures were used to analyse the data in this research:

(i) Statistical significance of correlation coefficient was established for the three questionnaires and the small scale experiments where appropriate. Spearman's correlation coefficient (Guilford 1950 P.310) was used to calculate the correlation between attitudes and success in mathematics; and between SES and success in mathematics. In some instances the chi squared test was applied.

(ii) Content analysis of the communication data gathered in the self image paragraph, the interviews, the observations and the non-formal interviews. Content analysis is a technique frequently used in behavioural research in order to make discussion about qualitative data possible in a scientific manner, or simply put: to convert recorded raw phenomena into quantifiable data (Cartwright 1953). The most acceptable definition of content analysis is that provided by Kerlinger (1986). Content analysis is a method of studying and analysing communications in a systematic, objective and quantitative manner to measure variables (P.477). This definition includes most of Berelson's original definition as quoted by Cartwright (1953, P.424) with simply the addition of "measuring variables" given as

the purpose of content analysis. The object of study in content analysis is no longer the individual but the communication. Cohen and Manion (1980, P.259) note that this technique can be applied to interviews and is especially useful in a focussed interview where the important elements have been previously ana ysed by the researcher.

One important aspect of the content analysis about which there is considerable debate is the breakdown unit of the recorded communication. Kerlinger (1986, P.479) quotes Berelson who lists units of analysis including: words, themes (which may be phrases or sentences) and items (which are one person's full recorded interview or an essay for example).

Cartwright (1953) uses the term "recording unit" to mean that segment of the content which gets labelled when the analyst codes the content and this may also be taken as the enumeration unit but it is not always appropriate to do so (P.441). Here the term "unit of content" is used to signify what was counted and it was generally a word or phrase. There are three steps in content analysis.

(i) Select the variables or the concepts to be recorded and the unit of content that will be employed.

(ii) Develop a category system for classifying units of content - this enhances the scientific validity by making the analysis more objective and systematic.

(iii) Quantification is linked to the categories in one of two ways:-

(a) enumeration of recorded occurences of each category;

(b) simple binary index Yes/No of whether the concepts in the coding scheme are present or absent (Polit and Hungler 1983, P.344 - 348).

The data collected from each instrument were therefore analysed in the following manner:

1. Questionnaires

Three questionnaires, those on attitudes, cultural beliefs and socio-economic status were administered to all the standard 7 students. These were scored as described in chapter 7 and chapter 9. Frequency distributions were constructed, together with means, maximum and minimum scores and standard deviations. Reliability scores were calculated by doing a split halves reliability test where appropriate and by calculating interscorer reliability and percentage consistency of response. Correlation coefficients between the scores and the mathematics score test marks on the one hand and between the scores and the picture problem performance on the other hand were calculated. Statistical significance was measured and reported. Finally the data were studied carefully for items which distinguished between students good at maths and students who are not good at maths. Where it was appropriate the variable was futher studied by deepening the investigation using a small scale test as described below in 5.

2. Self-image paragraph

The paragraph was divided into units of content. Categories were designed based on Minkowich et al (1982) as reported in chapter 9. The units were assigned to the categories. Two independent scorers were given a sample of the paragraphs and the categories for scoring;

an interscorer coefficient was calculated. The scores were tabulated and a frequency distribution constructed. Mean scores, maximum and minimum and standard deviation were calculated. Correlation coefficient between the self-image scores and each of the two criteria for success in mathematics were calculated and statistical significance measured. Students good at maths and students not good at maths were compared and findings reported in chapter 9.

3. Interviews

There were two parts in the interviews. First there was a general discussion about mathematics, with each subject which explored topics such as perceived view of themselves as maths students,their attitudes to maths, what characterises a good maths teacher etc. All this was recorded and subsequently broken down into categories as shown in appendix G. Some of this material was used for triangulation purposes to check on validity and reliability of the questionnaire material.
The second part of the interview consisted of talking each subject through each of five picture problems, as shown in Appendix B. The interview was recorded and a transcript prepared for each student. In general what was being researched was to find out if there was a connection between how a student performed in the picture problems and his ultimate success in giving the right

answer in a reasonable time. Units of content were selected from the transcripts - usually a phrase or a sentence as shown in chapter 6. Categories were designed based on Skemp (1979) as descibed in chapter 6. Scores were awarded in each category to make a maximum of 10 points. These scores were then used as the second criterion for success in maths as discussed in chapter 2 and correlations were calculated between this score and the independent variables as reported in chapters 7,and 9. Comparisons and similarities between the students who scored highly in the picture problems (i.e. score of 7 or more) and the students who scored low marks (i.e. score of 4 or less) are discussed and reported in chapter 6.

4. Observations and non-formal interviews

Because of the position of the researcher as a teacher in Phokeng it was possible to record a great number of observations and non-formal interviews throughout the research. Anything which was thought of as shedding light on the research question was noted such as comments at meetings, language used by students when working maths problems in roups, common errors in doing maths exercises etc.

5. Small scale tests

As the research progressed it became necessary to further deepen the investigation into some of the variables being studied. In chapter 7 the small scale experiments used to deepen the knowledge about socio-economic status and about how the degree of westernization affects mathematics performance are described and the findings reported. Because of the illuminative nature of the present research it was not possible to plan these small scale tests beforehand and hence they were carried out on samples of students drawn from the schools in the education unit being investigated but not on the same standard 7 group used in 1 to 4 above. In some cases it was students from std 5,6,7,8,9 and even matric students who provided the samples. In each case a group of students who were good at maths was coupled with a group who were not good at maths using the school maths mark as criterion.

In chapter 9 two other small scale experiments were carried out, one on the ability to disembed a simple figure from a complex one and the other to establish locus of control in self-concept. For these two tests the groups were standard 7 students who were matched for: age, school, standard, education level of father and father's occupation. The variable being investigated was how the performance in the test was related to school maths mark. The results of these small scale tests are reported in chapter 9.

CHAPTER 6

INTERVIEWS

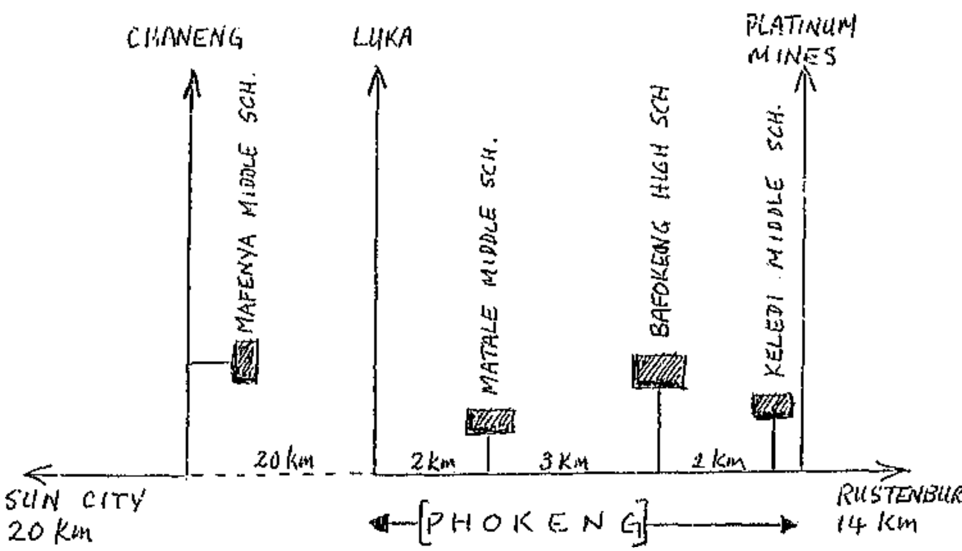
6.1. Background information

6.1.1. Introduction

The interviews were carried out, in so far as this was possible, under uniform conditions. The subjects were collected at the middle school and brought by the interviewer in his car to Bafokeng High School, a distance of a few kilometres, as shown in figure 6.1. During this time the interviewer asked each one his or her name and where they lived and something about themselves in order to get them used to his voice and accent and to lessen their anxieties. Since the interviewer was a frequent caller to the schools and well known to the teachers no student refused to be interviewed and none showed visible signs of stress. On arrival at the High School the subjects were brought directly to the science room and given some magazines and picture books to occupy them while waiting for their turn. Attached to the science room is a small preparation room 5m x 2m and it was in this room that each subject was interviewed individually by the researcher. Both interviewer and subject were seated at a small table sitting side by side. There was a piece of paper for rough work to be used at the subject's discretion. All thirty two subjects from

Keledi and the sixteen from Matale were treated in this manner. The twelve subjects from Mafenya were interviewed in a house situated near the school since it was too far to ferry them back to Bafokeng High School. The change of venue did not seem to affect the interview. When the subjects completed the interview they were asked not to discuss the problems with their companions and they were not allowed to stay in the science room where the others were waiting.

Fig 6.1. Approx distances between the schools surveyed



As far as the interviewer could observe the subjects honoured this promise but there was no possibility of controlling what happened once they returned to their own schools. No clear evidence of coaching was observed although two subjects did produce ready answers to one of the problems without being able to explain how they did it.

6.1.2. Assumptions

The interview technique is based on certain assumptions:

(i) subjects have sufficient fluency in English to express themselves;

(ii) subjects have sufficient reflective ability to enable them to describe what they are thinking;

(iii) interviewer has the ability to establish rapport with the subjects so that they are willing to be truthful in the interview;

(iv) the procedure for recording the progress of the interview would be objective in presenting an accurate record of what took place.

Other assumptions only became clear during the field work:

(v) when a subject did not answer it was assumed he or she did not know the answer;

(vi) a friendly subject who smiled and looked directly at the interviewer made a favourable impression and was more likely to be helped solve the problem than one who was shy;

(vii) the picture would assist the subject in understanding the problem.

These assumptions will be dealt with again in the conclusion to this chapter and the findings in relation to each one will be presented then, as well as some of the more serious difficulties encountered.

6.1.3. Procedure

The subject was seated at a table beside the interviewer and some general information concerning himself, his home, family, school, mathematics was obtained by direct questioning. Everything was recorded in longhand by the interviewer. This was a rather slow laboured technique but it was decided on after trials during the pilot study proved that using a microphone and casette recorder inhibited some students while others tended to put on an act using an artificial accent or tried to imitate some popular radio announcer. After the subject had settled down the interviewer said he wished to give some problems in mathematics and he wanted the subject to tell him everything he or she was thinking as they worked. The interviewer placed a blank piece of paper and a pen on the table near the subject and told him or her that they could use it for rough work if they wished. The problems were presented in the form of 25 x

20cm cards which had black and white line drawings. In each case there was a boy who was shown as speaking in Setswana - he gave his name and what he was doing. Then underneath the drawing was the question in English. All the required information was on the card. The subjects were presented with these cards one at a time and always in the same order. The cards are given in Appendix B numbers 1 to 5.

Some subjects went directly to the question in English and worked on the answer while others became occupied with the picture and ignored the question. In some instances subjects spent up to 10 minutes talking about the picture and made up a story about it. The interviewer allowed them to continue until they finished - this was usually indicated by the subject saying something like: "that's all I see here". In such cases the interviewer asked them to read aloud the question and sometimes it was also necessary to ask them what was the answer.

The Interviewer avoided directing the subject by questions and made conscious efforts not to show by facial expressions, nodding, or any other means that he approved or disapproved of what the subject said. While the subject was busy with the problem the Interviewer recorded eye movement, gestures, facial expressions as well as everything spoken and written and the time taken by the subject. On some occasions it was necessary to ask what the subject meant by such and such a symbol or how the subject arrived at an answer. Once an answer was arrived at the subject was asked whether he or she thought it was correct or not and how they knew or how they could check. The same procedure was used for each of the five problems with each of the sixty subjects but the actual course of the interview depended on the interaction between the subject and the particular problem and the interviewer. Each section was considered completed when the subject either got the right answer and was able to check it or could explain it clearly or else when the interviewer became convinced that the subject did not understand the problem and was unable to be helped to understand within a reasonable time. In some cases a subject spent up to fifteen minutes on one problem but generally eight minutes was regarded as the reasonable maximum time for any one problem.

6.1.4. <u>Content Analysis</u>

The categories designed for the analysis of the interview transcripts were based on Skemp's model of intelligence (Skemp 1979, P.49). Skemp describes intelligence - as discussed above in section 3.2.4 - in terms of that mental function which enables a person to move from a recognised present state to a desired goal state. This provided the rationale for the picture problems. The present state was given as a picture which provided all the data required to work the problem. The goal state was given by means of a question written in English underneath the picture. The interviewer was then able to observe how the subject dealt with each of these and how he or she moved from one to the other.

The categories are as follows:

Category 1 PERCEPTION

The subject understood the problem presented to him in the picture which included both drawing and words.

Category 2 OPERATION

The subject was able to decide which was the correct operation to use.

Category 3 STRATEGY

The subject used a correctly recalled strategy for carrying out the operation or else the subject was able to develop one.

Category 4 REALITY TESTING

The subject had some method of checking the answer and determining whether or not it was correct without recourse to authority.

Category 5 TIME

The subject could carry out all that was required and arrive at a correct answer within a reasonable time.

In each category provision was made for those who while unable to carry out the steps themselves nonetheless were able to be helped by the interviewer and they demonstrated that they understood what was being explained.

Table 6.1. <u>Scoring system for picture problems</u>

CATEGORY	SCORE	DESCRIPTION
1. Perception	2	subject tackled the question directly
	1	subject could be helped to understand
	0	subject unable to understand the problem
2. Operation	2	subject used correct operation
	1	subject could be helped to do so
	0	subject unable to see which operation to use or persisted in using wrong one
3. Strategy	2	subject used a correct strategy
	1	subject could be helped to develop one
	0	subject unable to work out a strategy
4. Reality testing	2	subject used the inverse operation to check the answer
	1	subject repeated the original steps
	0	subject unable to check for himself
5. Time	2	subject took less than four minutes
	1	subject took up to eight minutes
	0	subject took more than eight minutes

The scoring was done by awarding two points in each category making a total of 10 points as shown in table 6.1. above.

In this manner each subject was awarded a score out of 10 points and the result was expressed as a symbol and interpreted as shown in table 6.2.

Table 6.2. <u>Meanings assigned to picture problem scores</u>

SCORE	SYMBOL	INTERPRETATION OF PICTURE PROBLEM SCORES
9 or 10	A	very good at this test
7 or 8	B	good at this test
5 or 6	C	fair at this test
3 or 4	D	poor at this test
0, 1 or 2	E	very poor at this test

6.2. Problem Number 1

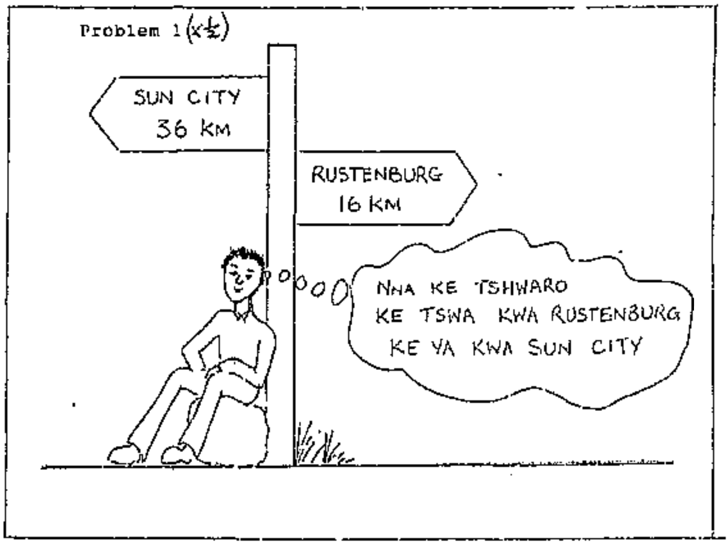
6.2.1. Description of problem

Problem number 1 consisted of a simple addition sum: 36 + 16 = 52

It was based on Hart (1981). The problem was in the form of a picture as shown in figure 6.2.

There is a boy sitting under a road sign which indicated Rustenburg 16 km to the right and Sun City 36 km to the left. The boy is saying in Setswana: "I am Tshwaro. I have come from Rustenburg and I am going to Sun City." Underneath the drawing is the question to be solved.

Fig 6.2. Picture problem No.1. (addition)



HOW FAR FROM RUSTENBURG TO SUN CITY?

6.2.2. How the students performed

There were great differences between the performances of students in this problem. Some were able to do it readily and after a short pause of as little as 1 or 2 minutes they could give the answer 52 km.

Olga Molefe 16 years old is in 7C at Mafenya:

S: I calculate this distance (Pointing to the sign board for Rustenburg) and this one (pointing to the sign board for Sun City) and I get 52 km. The distance from Rustenburg to Sun City is 52 km.
I: Is it correct?
S: (sighs) ... (pause) ...(hands together) ... Yes I'm correct.
I: How do you know?
S: Because I calculate the distance from Rustenburg to Sun City.
I: Can you check?
S: Yes ... (pause) ... I calculate 36 with 16. First 6 plus 6 it gives me 12 then I carry that 1 and go with that 1 ... this 3 and this 1 - it gives me 4

and I carry it with that and it gives me 5.

Interviewer notes that all the above description refers to what was going on in the subject's head - she was not writing anything on paper throughout this explanation. Olga took only 3 minutes to explain all the above but she had arrived at the correct answer in just under one minute. She was scored 10 points and given symbol A for this problem.

There were 6 students in all who were scored symbol A and they were the only ones who added from the start, the others all subtracted at first. A further 22 students realised their mistake readily and understood with a little help that they had to add the two numbers. None of these had any problems with the actual strategy but only 2 seemed to realise you could check addition by subtraction using the inverse operation. At the other extreme 21 students were unable to do this problem or in 10 cases even to comprehend what was required. In several cases after as much as 15 minutes the Interviewer failed to bring the subject to comprehend the problem and since the subject's confusion seemed to be getting worse moved on to the next problem.

Elizabeth Tsatsane 14 years old is in 7A at Keledi:

Subject took five minutes to describe the picture, then without any reference to the question underneath the picture continues:

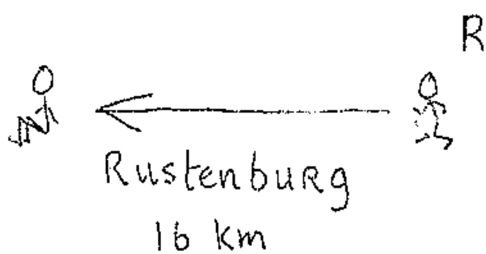
S: ... that's all I could describe ...
I: A go na le potso? (Is there a question?)

S: Eee ... (Yes) ... (silent) ...
I: Ga go na araba (there is no answer)
S: Eee ... (Yes) ... It is 20 km from Rustenburg to Sun City
I: Can you check your answer?
S: (silent) ... I have subtracted 16 from 36.
There followed an exchange about position and direction and distance to Rustenburg and Sun City.
I: How far from Rustenburg to Sun City?
S: 16
I: How far from Sun City to Rustenburg?
S: 36

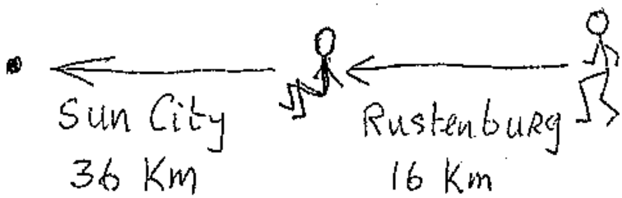
Since this seemed not to be leading anywhere Interviewer tried to explain using another diagram showing a boy sitting whom subject identified as Tshwaro and to the right a boy walking and "R" beside it. Subject takes a pen and writes "Rustenburg 16 km" as shown in fig 6.3 (a) Interviewer makes a dot to the left and draws an arrow. Subject writes "Sun City 36 km" on this line as shown in Fig 6.3 (b) Interviewer asks "How far from Rustenburg to Sun City?" (Interviewer draws a line from dot marked "R" to dot marked "Sun City" as shown in Fig 6.3 (c)).

Fig 6.3. <u>Method used to explain picture problem No.1</u>

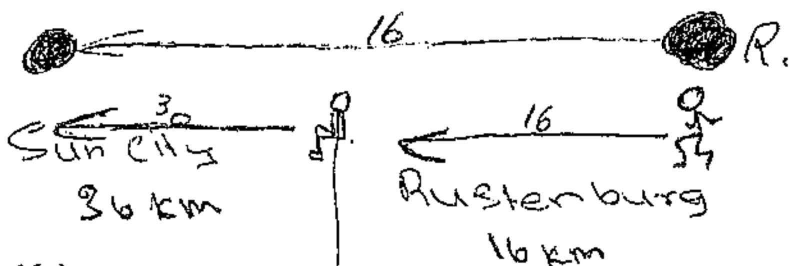
(a)



(b)



(c)



S: 16 km
I: How far from Sun City to Rustenburg ?
I: 36 km
I: If I go this way ? (indicating left to right)
S: 36
I: And if I go this way ? (indicating right to left)
S: 16

This had taken 12 minutes and the interviewer decided subject was not making any progress and moved on to the next problem. Subject was scored one point because had a clear knowledge that Tshwaro was in between Rustenburg and Sun City and not in either place, but no points could be scored in any other category for this subject. Seven students spent several minutes describing the picture and more time was taken up with the description by those who scored symbol E for this problem than by any others.

Gertrude Nameng 14 years old is in 7A at Matale:

S: Most people go to Sun City and don't do their homeworks ... and when they come to school she tells teacher she didn't do the work and when she fails she says the teacher doesn't teach them and its really themselves who make a fault ... (pause) ... that's all ... (silent) ... places like Sun City, recreational places, you must go there on holidays and not go there always ... you can go there once a month, that's ok ... The best way is to read ... before you go there ... (silent) ... I end there.

The subject had spent just over three minutes talking like this and still had not come to the question about how far from Rustenburg to Sun City. The interviewer had to intervene:

I: Is there a question on that card ?

Subject looks at the question at the bottom of the card in a surprised manner as if seeing it for the first time and then reads it aloud in English, pauses and then continues:

S: It's approximately 30 kilometres.
I: Why do you say 30 km?
S: Because it is written on the board at the boundary between our village and the town.

Interviewer realises that subject is not referring to the drawing but to the real life situation with which she is familiar at home, and there is indeed a sign board at the Phokeng boundary which says Sun City is 30 km. Later on this subject says Rustenburg is approximately 5 km in answer to a question and explains it is because Rustenburg is not as far as Sun City which is also true in real life if one is situated at Phokeng.

6.2.3. Comparison between good maths students and poor maths students

The results of the scoring for each school are given in Table 6.3.

Table 6.3. Scores for picture problem 1 for each student

SCHOOL	SYMBOL					TOTAL
	A	B	C	D	E	
Keledi	2	16	4	4	6	32
Matale	2	2	6	2	4	16
Mafenya	2	4	1	4	1	12
TOTAL	6	22	11	10	11	60

From this table it can be seen there were 28 who scored A or B and are described as "good maths students" for problem number 1. There were only two who scored the maximum of 10 points, the other 26 scored 7,8 or 9 points. The "good" students saw that they had to add 36 and 16 and they were able to do so readily without using the rough work paper provided. They knew they were correct and they could check either by repeating the addition on paper or by using the inverse operation. They showed a clear understanding of the picture and they took less than 4 minutes to do the problem. There were 21 students who performed poorly in problem number 1 scoring 4 points or less. This group subtracted instead of adding and they could not be taught in the time available that this was incorrect. Three of these were unable to do the subtraction properly. Preoccupation with the picture and a tendency to ignore the question underneath was another characteristic of this group. When they were made to read the question by intervention of the interviewer they tended to decide quickly that subtraction was what was required and they stuck to this throughout the interview, showing that premature closure was a tendency of poor performers.

A total of 15 students did not understand the picture and 11 of these said the post supporting the sign board was the tar road from Rustenburg to Sun City - all but one of this eleven are in the group of poor performers. It seems from this that one of the causes of difficulty for poor maths students is incorrect perception of 2-d drawings. Another perceptual problem for this group was their apparent difficulty in distinguishing between the names of the places Rustenburg and Sun City printed on the sign board and the places themselves which were supposed to be somewhere to the left and right many kilometres away. The good students pointed off to the left and to the right when asked where these places were and used words like "to the east/to the west". But the poor maths students just pointed to the names printed on the sign board. They seemed limited to the concrete, to what they could actually see in the drawing and seemed not to have been able to visualise the places off the drawing.

The adding or subtracting itself was not a serious problem for the majority of students interviewed.

Checking the answer was a big problem for the poor performers and they tended to rely on authority of the teacher (or during the interviews on the interviewer) to know whether or not they were correct.

Good students were able to deal with the problem in the abstract. Poor students confuse between real life and the picture problem.

eg. Gertrude Nameng told a real life story about Sun City and how students use it as an excuse for no doing their homework. This student also insisted that Sun City was 30 km from Rustenburg even though the picture problem showed 36 km on the sign board. She said on questioning that there is a sign board at the edge of Phokeng village which says Sun City 30 km from Phokeng.

Good students explored possible ways of finding an answer. Poor students tended to decide quickly that subtraction (incorrectly) was the right thing to do and were unable to consider alternatives. Premature closure and persistence in answer first attained was a characteristic of the poor students.

Good students could readily interpret the picture and showed no difficulty in visualising places not actually in the picture but only indicated by a sign board.

Poor students had problems with 2-d perception and misinterpreted the drawing - they thought the post was a tar road and they could not visualise that Rustenburg was off the picture to the right. They insisted on pointing to the name Rustenburg printed on the sign and seemed not to realise Rustenburg was not on the sign but was somewhere to the right.

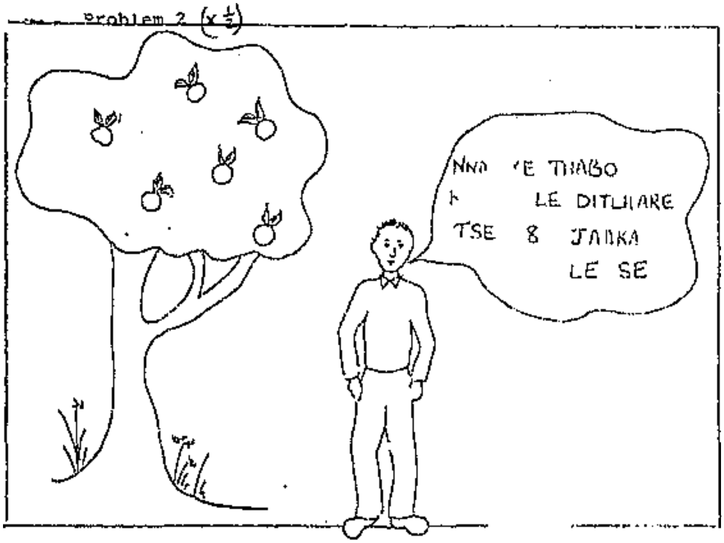
Finally it must be remembered that only students classified by their teachers as "good" or "average" in mathematics were in the sample interviewed and none who would be classified as "weak maths students" by the teachers were included. Therefore it can be said there are huge gaps in the mathematics achievement of the std 7 students sampled.

6.3. Problem number 2

6.3.1. Description

Problem 2 was a multiplication sum: 6 x 8 = 48. It was presented also on a card with a line drawing which showed an apple tree with six fruit and standing beside the tree was a boy saying in Setswana "I am Thabo. I have eight trees just like this one." Underneath was the question written in English as shown in figure 6.4.

Fig 6.4. Picture problem No.2 (multiplication)



HOW MANY APPLES DOES THABO HAVE ?

6.3.2. How the students performed

The categories for the analysis of problem number 2 were the same as used for the previous problem. In general the performance was similar to that for problem number 1 with regard to the numbers who were able to do it and the time taken. One very obvious point of difference was that while selecting the right operation was the major difficulty in problem number 1, this was not so for problem number 2 and almost all the students knew they had to combine 6 apples eight times in order to find the answer required. The biggest difficulty here was in the strategy - only 17 of the 60 students interviewed used the recalled number fact: 6 x 8 = 48 and five of the 17 got it wrong saying 6 x 8 = 42, 80 or 64 and they were unaware that it was wrong and could not check it. Many others wrote on the rough work paper: 6 x 8 = and left it blank while they went to another part of the paper and added up the multiples of 6 or whatever and only afterwards returned to the original place and completed: 6 x 8 = 48. Six students were unable to understand what was required to do the problem even after lengthy guidance by the interviewer. As with problem number 1 the difficulty for these six seemed to be a perceptual one in the sense that they were unable to visualise other trees similar to the one shown in the picture even when the interviewer made drawings of other trees they insisted that these extra trees had no apples.

Jan Ntsimane 19 years old is in 7B at Keledi:

S: I see a man ... he tells us about the trees ... (Subject looks closely around the picture - eye movement to the right and to the left as subject examines it in detail) ... his name is Thabo ... he has eight trees ... (subjec pauses ... arms folded) ... eight apples ... I see the tree and the grass (subject points to right hand side of picture) ... (silent) ..
I: What is the question?
S: How many apples does Thabo have? (subject reads aloud) silent
I: And the answer?
S: Six apples
I: is the answer correct?
S: Yes its correct because I have add these apples (subject taps the apples drawn in the picture with his pen)
Interviewer draws a tree on the rough work paper

I: Here is another tree
S: Yes
I: How many apples?
S: I don't know because there is no apples

The problem was abandoned after a few more exchanges like this one. This subject was given the symbol E, for problem number 2.

A total of eleven students got symbol A compared to only six who got A for problem number 1 although only two scored the maximum ten points in problem number 2 the same number as scored maximum points in problem number 1: One of these was Godfrey Matshana who is 14 years old and is in 7B at Matale:

S: I think I'm going to multiply this six apples on the tree and see how much the answer is going to be ... (pause) ... Hm ... Hm ... forty eight apples (silent)
I: Is it correct?
S: Yes
I: How do you know?
S: I have multiplied six apples by eight and I got forty eight. Subject writes 6 x 8 and draws a line underneath and writes 48. I can divide 6 by 48 and I get 8.

Subject writes 48 and draws a line underneath and writes 6 and then to the right hand side writes 8 and underscores it.

Godfrey had taken just under one minute to get the right answer and one minute to explain to Interviewer how he checked it. He was given a score of 10 points and given symbol A for this. Just as with problem number 1 several students spent time describing the picture saying how the boy "was proud of his trees" or "he had worked hard to grow these trees".

Jairus Mothusi Seketi is 17 years old in 7C at Keledi:

> S: This boy says my name is Thabo. I have eight trees as this one. Now I have only got five apples ... those apples I sell to the people ... but I found just a little profit from these apples. (pause) ... (coughs) ... (sighs) ... these apples are very sweet ... all people need them ... some people steal them but I don't know why they make this ... I found two boys on top of one of these trees they were eating while I was coming to them they threw me with those apples which were not ripe ... (pause) ... Out of those eight trees I was left with one tree ... Those people who stole my apples I tell the police and take them to the jail ...

Interviewer noted subject had finished and was not prepared to say anymore. This story had taken just over four minutes and the subject had still not got started on the question to be solved. With help from interviewer Jairus was able to arrive at the answer 48 apples. He was scored 4 and given symbol D.

6.3.3. <u>Strategies used in working Problem number 2</u>

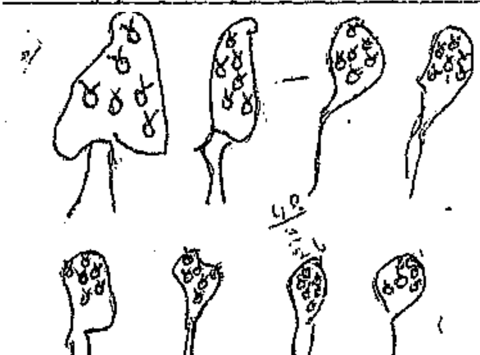
The students differed considerably in how they went about the task of finding an answer to the question posed in problem number 2. The greatest number used the multiplication tables, generally the six-times tables and usually they were able to recall 6 x 8 = 48. Four different strategies emerged from the analysis of the transcripts which can be identified as: (a) simple counting, (b) repeated addition, (c) applied number fact, (d) recalled number fact.

Each of these is now described using illustrations from subjects responses and drawings on the rough work paper.

(a) simple counting:

Subject made a drawing of eight trees and on each tree sketched six apples as shown in fig 6.5. and then subject proceeded to count 1, 2, 3, 4, 5, 6, (on the first tree and moved to the second tree) 7, 8, 9, 10, 11, 12, (then to the next tree until all the apples had been counted).

Fig 6.5. Solving picture problem 2 by drawing trees



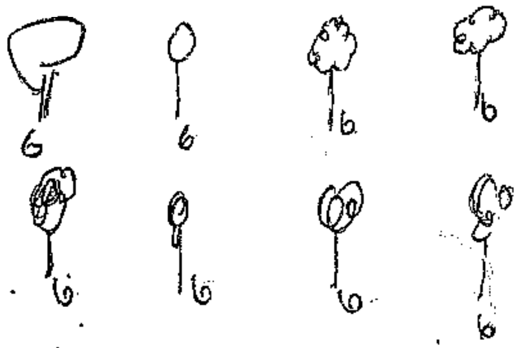
Only one subject used this strategy - a girl aged 17 years. This subject when asked to check the answer wrote down 48 and under it wrote 8 and then a line and under the line the number 6. When asked what she was doing she replied:

> S: I'm trying to divide ... this (pointing to 8) times this (pointing to 6) is 48.

(b) repeated addition:

There were two varieties of repeated addition - some relied on drawings of trees and counted in multiples of six, as shown in fig 6.6. others simply used numbers.

Fig 6.6. <u>Solving picture probl.m 2 by counting in sixes</u>



(i) counting in multiples:

Subjects made drawings of eight trees and then counted 6, 12, 18, ... up to 48

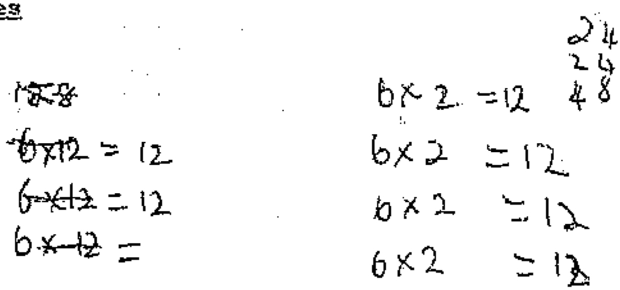
(ii) repeated addition:

subjects wrote down 6 + 6 = 12 then 6 + 12 = 18 etc until they got 48. They usually did this addition vertically.

(c) applied number fact:

There were also two varieties of applied number facts - subjects applied the number fact of two-times tables previously learned or else they applied the facts of structure of numbers in terms of smaller numbers.

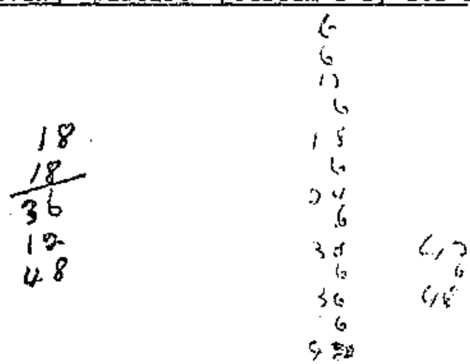
Fig 6.7 <u>Solving picture problem 2 by use of two times tables</u>



(i) application of two times tables:

step 1: subjects wrote a series of sixes:
step 2: subjects wrote number 12 underneath
step 3: subjects wrote number 24 under these
step 4: subjects wrote number 48 under these

Fig 6.8. <u>Solving picture problem 2 by use of applied number fact</u>



(ii) break down of big numbers into smaller numbers:

step 1: subjects wrote 18
step 2: subjects wrote 18 again and drew a line
step 3: subjects added 36
step 4: subjects wrote 12 underneath
step 5: subjects added 48

In such cases the subjects had seen that the number "8" could be broken down into 3 + 3 + 2 then they multiplied 3 x 6 = 18 and repeated this and then added the two eighteens and then multiplied 2 x 6 = 12 and added this to the 36 to get 48

(d) recalled number fact:

Usually the subjects could recall 6 x 8 = ⁄ˑ but some subjects had to work up through the tables from 6 x 1 are 6, ɒ x 2 are 12 etc till reached 48. Some subjects had a difficulty knowing when to stop and one subject had to go as far as 80 and work backwards to 48 to check the answer.

The numbers using these different strategies were as follows:

(a)	Simple counting	1
(b)	Repeated additic.ɴ	20
(c)	Applied number fact	16
(d)	Recalled number fact	17
		54

The remaining 6 were unable to do the problem ˈecause they could not conceive of other trees with the same number of apples on them.

6.3.4. Com. .ᵗ ˈ ˈn ɔetween good maths students and poor maths student.

The main differences between good and poor mathˈ students as seen from the analysis of problem number 2 was that the level of abstraction shown by the good maths students appeared to be much higher than that shown by the poor maths students.

Table 6.4. shows how the two groups performed using the categories given in 6.3.3. and again using the symbols A and B for good and the symbols D and E for poor maths students.

The strategies used demonstrate different levels of abstraction. Those subjects unable to devise a strategy for this problem seem not to be able to work at any abstract level at all - even that of visualising other trees with similar numbers of apples.

In (a) below the subject seems limited to the drawing of apples which can be counted. In (b) the subjects demonstrate the ability to deal with number instead of apples or drawings of apples. In (c) the subjects are dealing with structure of numbers and are no longer confined to apples or drawings, and they can recognise patterns within the numbers. In (d) the subjects can apply previously learned number facts. Students who scored symbol C in problem 2 are not included in Table 6.4.

Good students could recall the number fact 6 x 8 = 48. Poor students sometimes wrongly recalled 6 x 8 = 64 etc. and were not able to check the answer in any way.

Good students had no trouble understanding there were 8 trees each with 6 apples. Poor students had difficulty in imagining trees which were not shown in the drawing.

Good students dealt with the problem abstractly - used numbers and recalled or applied number facts.

Table 6.4. Comparison of students by strategy used

STRATEGY	STUDENTS GOOD AT MATHS	STUDENTS POOR AT MATHS
(a) simple counting	0	1
(b) repeated addition:		
(i) multiples	5	4
(ii) repeated addition	2	4
(c) applied number fact		
(i) two times tables	2	4
(ii) number structure	3	0
(d) recalled number fact	14	1
Unable to do the question	0	6
TOTALS	26	20

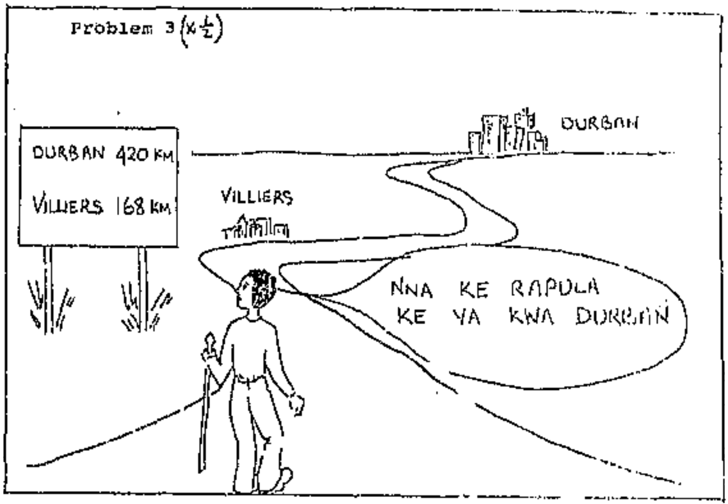
Poor students limited to the picture or other drawing of trees made by themselves or researcher.

6.4. Problem number 3

6.4.1. Description of problem

Problem number 3 was presented just like number 1 and number 2 in the form of a picture which showed a man standing looking at a sign board on which was written "Villiers 168 km Durban 420 km". The man is shown speaking in Setswana: "I am Rapula. I am going to Durban".

Fig 6.9. Picture problem number 3 (subtraction)



HOW FAR FROM VILLIERS TO DURBAN?

6.4.2. How the students performed

Problem number 3 proved to be the most difficult of the five problems for the sample of sixty students interviewed. In all, 19 students failed to arrive at the correct answer even after a lot of help from the interviewer.

Johannes Nong 18 years old is in 7C at Keledi:

S: I see a man here ... his name is Rapula ... he is going to Durban ... and Durban is 420 kilometres. (subject writes on rough paper as shown in Fig 6.10.) from Villiers to Durban is 588 kms.
I: What does this board tell you? (pointing at road sign)
S: 420 km to Durban

I: From where?
S: From Villiers.
I: What else does the board tell you?
S: 168 km to Villiers
I: From where?
S: From Durban. (Subject again writes on paper)

Interviewer again challenges subject whether it is correct and repeats the same line of questioning as before and after another 5 minutes unable to change subject's thinking abandons this problem. Scored 0; given E.

Fig 6 10 Solving picture problem 3 by addition

420km
168km
588 km

168 km
420
588 Km

420 km
168
588 Km

This subject had decided early on that addition was the correct procedure and he maintained this position throughout. This is an example of premature closure and persistence in the wrong plan which was a charateristic of those who performed poorly in the picture problems.
The usual method used by Interviewer when trying to help students understand the problem was to use three pieces of chalk or pens one each to represent Rapula, Villiers

and Durban. It was found that some students were able to understand the problem when they could manipulate objects and it is possible that the trouble they had with the picture was the inability to interpret correctly 2-d drawings. Some however were still unable to do the question even when simple numbers were used.

Cleophas Kgamphe 15 years old is in 7C at Keledi:

S: This boy is Rapula ... he went to Durban ... (pause) ... he ... (subject's eye movement indicates searching all over the picture) ... (silent) ... (hand at forehead) ... (silent for one minute) ...
I: What is the question?
S: ... (silent) ... (fidgets with left hand) ...
I: What is the question?
S: (reads aloud in English) How far from Villiers to Durban?
I: What is the answer?
S: It's 588 kilometres (subject had calculated this in his head)

When challenged subject remained silent - presumed by interviewer that subject did not understand the problem. Interviewer then placed a piece of chalk on the table and said this is where Rapula is standing, then invited subject to indicate where Villiers and Durban were respectively which he did successfully and with renewed interest on his face. When asked about distances subject could identify correctly 168 km from Rapula to Villiers but struggled with the 420 km from Rapula to Durban. Subject appeared to have fixed in his mind that 420 km was distance from Villiers to Durban and was unable to change that. Interviewer then made marks on the rough work paper as shown in fig 6.11. And marked 5 and

2 as shown below. When asked how far from V to D subject remained silent and it was presumed he did not know. Cleophas was scorea 0 and given symbol E. This had taken nine minutes and Interviewer moved on to next problem.

Fig 6.11 <u>Solving picture problem 3 using simple numbers</u>

Four students scored maximum points for this problem and they had no difficulty with it and were able to explain the answer as being correct because they could use the inverse operation to check it.

Catherine Pitsoe 13 years old is in 7B at Keledi:

S: In this picture they want to know the distance from where the man is to villiers ... No ... to Durban ... On the board they show distance from this man to Villiers and from this man to Durban ... here (subject points at picture) is Villiers ... here is Durban (subject points at the place Durban) ... The question is how far from Villiers to Durban ... (subject takes rough work paper and pen writes 420 and underneath 168 draws line and subtracts and gets 252) its 252 kilometres.

Interviewer notes all this had taken just two minutes and subject was very confident about answer and was able to explain easily how she had arrived at the answer and why she had subtracted and how to use the inverse operation to check:

> S: When you add 168 km to 252 kms it will give you 480 kms which is the distance to Durban from where Rapula is standing.

Catherine was scored 10 poi^'s and given symbol A. As with the other problems the picture in problem number 3 distracted several students and twelve students spent time describing it or making up stories.

Magdeline Diale 17 years old is in 7B at Keledi:

> S: This man ... his name is Rapula ... he is going to Durban and Durban is 420 km from Villiers and Villiers is 168 ... I think Durban is not far away from Villiers because he can go there by foot. I think Villiers is a rural settlement and he is going to Durban to relax because it is an urban settlement. I think it is summer time because many people go to Durban in the summer because they can swim there. ... (pause) ..., and the distance is 588 from Villiers to Durban ... and I think he is going to suffer because it is a long way ...

This subject was able to be helped to understand the problem and eventually got the right answer. She was scored 4 points and given symbol D.

There were difficulties in both the operation and the strategy in this problem. Over half the students - 31 of the 60 - added first instead of subtracting. Eleven students made mistakes in the subtraction sometimes in the tens sometimes in the hundreds.

The role of the interviewer also got confused during the interviews in this problem and in a few instances role of interviewer and subject became reversed.

Jeanette Setshwane is 14 years old in 7D at Keledi:

S: from Durban to Villiers its 352 because 420 subtract 168 is 352
I: Is there some way to check your answer?
S: (silent) ... (finger pulls at lips) ...
I: What do you think?
S: I think nothing
I: Is 352 correct?
S: Yes
I: Can you check it?
S: (silent) ...
I: If I tell you that you are wrong what will you say?
S: I say give me the correct one
I: 252
S: How did you get it?
I: I subtract 168 from 420

Jeanette was scored 4 points and given symbol D.

6.4.3. Strategy used in problem number 3

Only 5 students did the subtraction in their heads all the others who subtracted used one of two methods: which will be referred to as (i) decomposition and (ii) equal addition respectively.

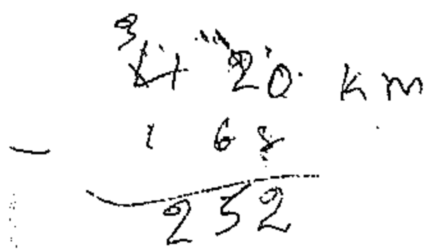
(i) Decomposition

In this method the subject wrote 420 and underneath 168 and made a line, Then subject stroked out the 0 and wrote 10 for the units and subtracted 8 from 10 and wrote 2 under the 8; next the subject stroked out the 2 in the top line and wrote 11 and then subtracted 6 from 11 and wrote 5 under the twenties column; finally the subject stroked out the 4 in the top line and wrote 3 and then subtracted 1 from 3 and wrote 2 for the hundreds column. One example of this method is shown in Fig. 6.12.

Amanda Morokwane 17 years old is in 7C at Matale:

> S: I take one from here from two and put one here from naught and it will be one here where was two then ten minus eight is two - here is one I take one from four is eleven minus six the answer is five ... three minus one is two.
> 29 students used this method.

Fig 6.12 <u>Solving picture problem 3 by decomposition method</u>



(ii) Equal addition

The method used here was not essentially different from the one above except in the manner of "borrowing" and "carrying". The subjects did not stroke out numbers in the top line but simply wrote a small "one" to the left of the zero in the units column and another small "one

in the tens column to the left of the 2. In working the subtraction they carried one from each column. This method is shown in Fig. 6.13.
Only five students used this method.

Fig 6.13. <u>Solving picture problem 3 by equal addition method</u>

$$\begin{array}{r} -\ 4\,2\,0 \\ 1\,6\,8 \\ \hline 2\,5\,2 \end{array} \qquad \begin{array}{r} +\ 168 \\ 252 \\ \hline 420 \end{array}$$

6.4.4. <u>Comparison between good maths students and poor maths students</u>

The symbols scored by each school are given in Table 6.5.

Table 6.5. <u>Scores for picture problem 3 for each school</u>

SCHOOL	SYMBOL					TOTAL
	A	B	C	D	E	
Keledi	4	6	7	3	12	32
Matale	3	4	3	2	4	16
Mafenya	3	4	2	0	3	12
TOTALS	10	14	12	5	19	60

As can be seen from this table the performance of students in the different schools varies considerably. Mafenya students did much better than the others and Keledi worse than the others. When the scores for the separate classes were analysed this difference became more evident.
The symbols scored by each class are given in Table 6.6. where the average score for each class is given.

Table 6.6. Scores for picture problem 3 for each class

SCHOOL	CLASS AVERAGE			
	7A	7B	7C	7D
Keledi	6,4	5,0	1,5	4,1
Matale	7,0	4,8	3,5	5,5
Mafenya	8,5	5,0	3,8	-

It can be seen that Class 7A Mafenya had the highest score and Class 7C Keledi had an extremely low average score by comparison with the other classes. The variables involved in different classes are not simply confined to having different teachers (which is true), nor different numbers of students in the class (which is also true) but the selection process within the school itself - some schools put only their best students in a given class and others put all the repeaters together and so on so that it is difficult to find any simple explanation for such different averages as shown above. Some school variables including teaching style of the teachers are discussed in chapter 8 below.

No clear differences between good maths students and the poor maths students could be found in the time spent describing the picture nor in the numbers who made mistakes in the subtraction.

There was a clear difference between the two groups in their ability to select the right operation. Most of the good maths students went straight to subtraction and only three of the 24 good maths students added first. On the other hand, out of the 24 poor maths students sixteen added first and only five of these could be taught that they must subtract in order to do the question correctly. The ability to understand the picture correctly and to recognise the positions of Rapula, Villiers and Durban was another serious difficulty for the poor maths students and nineteen of them were unable to comprehend it even after help. This seems to be the same perceptual problem as was encountered already in problem number 1.

Good students selected the correct operation and subtracted.

Poor students added first and it proved very difficult to change them from addition to subtraction in the time available for the interview.

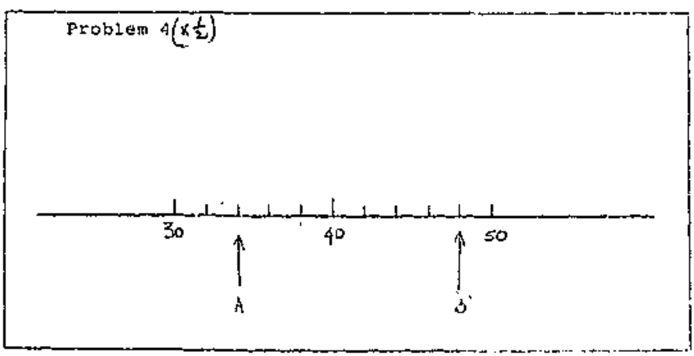
Good students understood the picture readily. Poor students had great difficulty in abstracting from the picture to a line and understanding they were being asked the distance from Villiers to Durban. They could say the words but they could not relate the distances given to the words spoken.

6.5. Problem number 4

6.5.1. Description of problem

Like the others, problem number 4 was presented on a card 25 x 20 cm. There was a line marked off in 10 sections and labelled as shown.

Fig 6.14. Picture problem number 4 (number line)



WHAT NUMBER IS SHOWN AT 'A'? AT 'B'?

At the bottom of the card was written the question: What number is shown at A ? at B ?
This problem differed from the others in that there was no real picture as such and no drawing of a man speaking something in Setswana. This problem was included to test the students ability to identify correctly number intervals other than unit intervals and to observe how they would handle such a problem.

6.5.2. <u>How the students performed</u>

Problem number 4 seemed to be the easiest of the five problems and eight students scored the maximum 10 points and another fourteen scored 9 points which meant altogether 22 students got an A symbol for this problem. Most of this group were able to give out the answer directly and quickly either knowing it intuitively or else working out the answer in a systematic manner.
Dolphine Letshedi 15 years old is in 7A at Keledi:

S: I see the number line ... the numbers 30 and the A and stroke shown at the point and the 40 and the stroke at B and the number at the 50 and the question ... I think the number at A is 34 because it is the second point from 30 to 40 and there are five points ...

When challenged and asked if A was 32 subject replied

S: No because here (subject points to 40) is not 35 ... I start by counting the even numbers from 30 to 40 and it is the second one.

All this took under three minutes.

Dolphine was scored 10 points and given the symbol A.

Eleven students were unable to deal meaningfully with this problem even after help from the interviewer. Five students interpreted the question literally and said (correctly) "There is no number at A". Three of these were able to work out the question after some guidance but the other two refused to recognise the possibility of any other than "no number at A"

The major difficulty which this group seemed to have was associating equal length intervals with equal numbers.

Gertrude Nameng 14 years old is in 7A at Matale:

S: On this paper there is a number line ... (pause) ... and the question reads thus (subject reads aloud in English) What is the number at A and at B ? ... (fiddles with pen) ... (pause) ... and the answers ... the arrow that points ... there is no number here and here (pointing at A and B) ... (silent) ...

I: What number should be there ?

S: (pause) ... (points pen at A) ... I think it's 25 ...

I: Is it correct ?

S: (smiles) ... I don't think so, because I have guessed ... I said 30, 20, 25 ...

I: What are the numbers between 30 to 40 (pointing to number line)

S: 30, 32, 33, ... (subject frowns ... not satisfied with answer) ...

I: What is the next number after 30 ?

S: 31, 32, 33, ... (interviewer points to marks between 30 and 40) (subject continues to count until reaches 40 and is now saying 35) (subject skips back and says 39 in place of 34 and now counts thus:

S: 30, 31, 32, 33, 39, 40... (subject pauses not yet satisfied)

S: 30, 35, 36, 37, 38, 40 ... (subject frowns) I have a problem here. Interviewer helps by pointing to spaces in between the marks while subject counts 31, 32, 33 ... etc up to 40 which is now correct)

I: What is at A ?

S: 34 and at B is 48 (subject shows how to find answer still counting in ones.)

There were no stories made about this problem and most students recogn sed it as a number line, those who did spend time at it generally gave a straight forward description of what they saw.

Daniel Mokoena 17 years old is in 7B at Matale;

S: Here is a number line ... here is a straight line and an arrow showing at A and an arrow showing at B ... (subject takes the rough work paper and draws a line and puts in five little lines and marks 30 and 40 and makes an arrow labelled A etc just as in the question) ... so here at A its 34 ... (places pen to forehead) and at B is 48.

This took two and a half minutes. Subject was able to explain how to get the answer by a trial and error technique. Daniel was scored 9 points and given symbol A.

One boy mistook the picture for a lever and fulcrum that he had learned about in physical science class - presumably the reason for this was because of the arrows, since in science diagrams the levers are often represented as shown in Fig 6.15. in text books.

Fig. 6.15. Illustration of action of forces for common lever

Matale students scored much higher than the other two schools in this problem and Keledi again had the worst performance which can be at least partially explained from the overcrowded classes of up to 80 students per room.

6.5.3. Strategies used in working problem number 4

Only two strategies were used by the students in working problem number 4 that could be observed by the interviewer which will be referred to as (i) systematic and (ii) trial and error. Many students did the problem in their heads and were unable to explain how they arrived at the answer - they are listed in the table below as (iii) intuitive and the fourth group (iv) confused, didn't understand number intervals and were not able to work any solution

(i) Systematic:

Those who used this strategy subtracted 30 from 40 to get 10 which they recognised as the number of units between these two marks. Next they counted the number of strokes and got 5 strokes or 5 intervals. The third step was to divide the ten units by five intervals to get two units per interval. Finally they counted two intervals from 30 to reach point A and this gave them 34 as the answer. They were able to check by continuing to count and the fifth interval should be 40 and this coincided with the information given on the number line proving they were right. They used the same strategy for finding B.

(ii) Trial and error:

The students using this strategy concentrated only on the 30 and counted in ones up from 30 and thought A was 32. Similarly B was 44. Usually they were satisfied with this answer - although some did check for themselves and found their mistake. Most however had to be forced by the interviewer to continue their counting through A until they reached the point marked 40 and found themselves saying 35. At this stage most students went back again to 30 and this time counted in twos and found they were counting 40 when they reached the point marked 40 and hence they said that A must be 34 not 32. Similarly for B = 48.

(iii) Intuition:

The students who gave out the correct answer may have been using one or other of the above strategies or some other one - they could not or would not explain how they got the answers.

(iv) Confused:

This group included students who counted in ones as far as 34 and then skipped all the numbers in between and said the next number was 40 - in one instance actually tapping the space between what they called 34 and the point marked 40 five times saying 35, 36, 37, 38, 39. Another student insisted A was 30,5 and B was 40,5. What seemed common to all of these was a lack of understanding of the idea that equal line intervals must represent equal number intervals.

Table 6.7. The numbers using each strategy in picture problem 4

STRATEGY	SYMBOL SCORED					TOTAL
	A	B	C	D	E	
(i) Systematic	7	2	2	0	0	11
(ii) Trial & Error	5	6	7	7	0	25
(iii) Intuition	7	3	3	0	0	13
(iv) Confused	0	0	0	0	11	11
TOTALS	19	11	12	7	11	60

6.5.4. Comparison between good and poor maths students

Of the strategies described in the previous section, students using the systematic approach were regarded as working at a higher level of abstraction than those who relied on the trial and error method. Nine of the good maths students used the systematic strategy and eleven used the trial and error method. None of the poor maths students used the systematic strategy and seven of them used the trial and error method.

The good maths students took much less time in arriving at the right answer - usually two to three minutes as compared to the poor maths students who took almost twice as long.

The group of poor maths students seemed, as noted for the other problems, to have difficulty in visualising anything other than what the drawing showed. Some could not imagine any number at A or B. Others could not imagine any numbers in between the lines shown. And others could not picture equal intervals of length to correspond with equal number intervals.

The group of good maths students could check whether the answer they gave for A and for B was consistent with the given information but the group of poor maths students didn't seem to realise there was a contradiction or if they did then they concluded that the information given was wrong and that where the diagram indicated: 40 should have been 35. It was interesting to note that they accepted the given information that 40 was 40 when they then came to saying what B represented - they said it was 44 and then concluded that where the diagram had 50 was incorrect and this should be 45.

Good students experienced no trouble in this picture problem. More students scored 9 and 10 points in this problem (number line) than in any other problem. Some got the answer intuitively and were unable to explain how they arrived at it but were quite certain they were correct. Others answered systematically: 10 numbers (integers) and 5 marks therefore each mark represents a jump of two integers. Poor students simply counted in ones for each mark even though there were not enough marks to fit with the information given. They had a problem in apprehending that 30 to 31 must be the same length in this number line as 34 to 35 and they saw no apparent contradiction in saying 30 to 31 interval was the same length as 34 to 40 interval.

Good students had no problem playing the game of the picture problem and dealing with the question "what number is shown at A" when in fact no number was shown there. Poor students sometimes replied literally that "no number was shown at A"

Good students used systematic or intuitive strategy. Poor students took the easy approach and counted in ones - they were able to check but didn't do it by themselves. However when forced to continue counting through to the last written number which was given in the picture as 40 they found themselves saying 35 and only then realised this error.

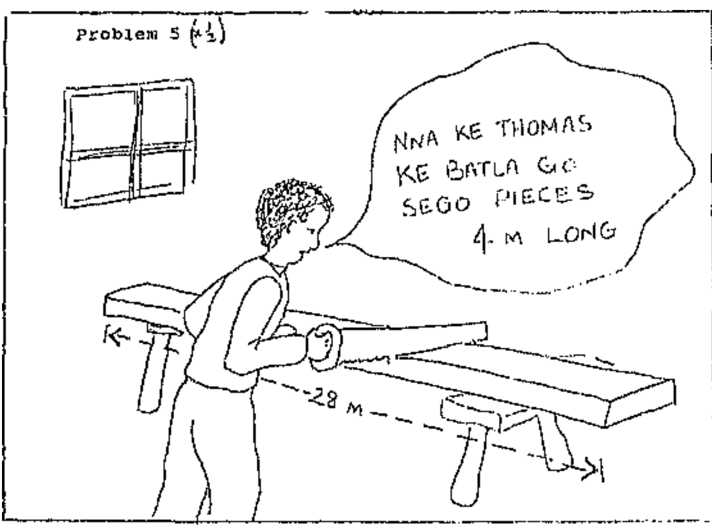
6.6. Problem number 5

6.6.1. Description of problem

Problem number 5 was a simple division 28 ÷ 4 = 7

It was presented in the form of a picture showing a boy cutting a plank. The length of the plank was shown by means of dotted lines from end to end just as is common in mathematics text books. The boy was saying in Setswana: "I am Thomas. I wish to cut pieces which are 4m long." The student had to determine the present state from the information given.

Fig 6.16. Picture problem 5 (division)



HOW MANY 4M PIECES CAN THOMAS GET FROM THIS BOARD?

All the data required to deal with the question were given in the picture or else in the words. There were three pieces of information given which the subject had to be able to extract in order to deal with the question:

(i) Thomas had a plank which was 28 m long;

(ii) He wished to cut this plank into pieces;

(iii) Each piece must be 4 m long.

6.6.2. How the students performed

There were more students classified as "good" on their performance in this problem than in any of the other five. altogether 37 students scored A or B for this, which indicates that many of them found it very easy. Johannes Moteane aged 17 years is in 7D at Keledi:

> S: There is a boy cutting a board ... how does this (subject points at the 28 m) ... is it 28 m? ... the question asks how many pieces ... (pause ... looks upwards ... thumb on chin) I think the answer is 7.
> I: why do you say 7?
> S: Because I divided 28 metres by 4 ... in order to get how much can Thomas get pieces from this board ...
> I: How did you get the answer ?
> S: It is in my head.
> I: Can you check it to find out if it is correct?
> S: Yes I divide and to check I multiply 7 by 4 and it gives me 28.

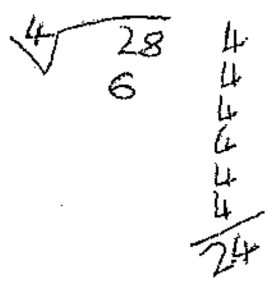
The other 23 students struggled with this problem and while some like the eight who scored a symbol C were able to understand after help from the interviewer, others like the ten who scored a symbol E were unable to do the problem even after coaching, and failed to arrive at any reasonable answer.

Martha Setshoane aged 17 years is in 7B at Mafenya:

S: I see a boy etc ... (subject describes picture) ... pause ... (eventually subject gets to the question at the bottom of the picture) ... He can get six pieces in this board ... (silent)
I: Is it correct ?
S: Yes
I: How do you know ?
S: I divided 28 metres by 4 metres
I: Can you check ?
S: Yes ... (subject takes pen and writes on the rough work paper and then writes 4 and under it 6 and says: I multiply 6 by 4 ... when I multiply 4 by 6 it gives me 28 ... and 6 into 28 goes 4 times.

Interviewer asks subject to write down 4 and under it another 4 until subject had six of them all in a row and then asked the subject t add them which she does and wrote down 25 and then stroked out the 5 and made it a 4 so she had added the six fours to get 24 as shown in Fig 6.17.

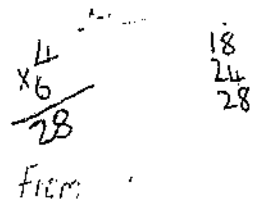
Fig 6.17. <u>Solving picture problem 5 by repeated addition</u>



I: How many 4m pieces can Thomas get from this 28m board ?
S: 6 (subject sticks to her original answer in spite of just having added six fours and got 24)
I: Is it correct ?
S: Yes

I: How do you know ?
S: I multiply 6 by 4 and I get 28 (subject writes 4 and 6 and a multiplication sign and a line and says) six times four is 28 (subject writes 28 as in Fig 6.18.

Fig 6.18. <u>Wrong multiplication in solving picture problem 5</u>



All this had taken just over eight minutes and the problem was abandoned since the subject did not seem to understand the connection between addition and multiplication and saw no contradiction between saying on the one hand that 6 x 4 = 28 and on the other hand adding up 4 six times and getting 24.

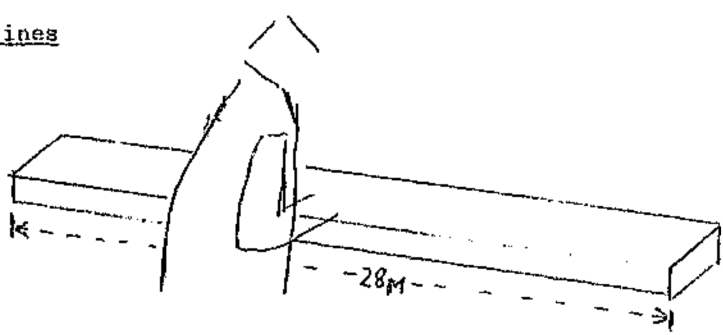
This is another example of premature closure which characterised the students unable to do the picture problems correctly.

The subject was scored 0 points for this problem and given symbol E. Fifteen students had problems understanding the picture. Usually the "28m" showing the length of the plank was the difficulty and several thought the plank was 56m long, but some thought the boy wanted to cut the plank into halves because the drawing showed him working at the middle, and still others were confused about the question at the bottom which asked about 4m pieces and they only saw the "4" and the word "pieces" and thought the boy wanted "4 pieces" not "4 metre pieces". After the dicussion with the interviewer these difficulties were sorted out but not always.

Magdeleine Diale aged 17 is in 7B at Keledi:

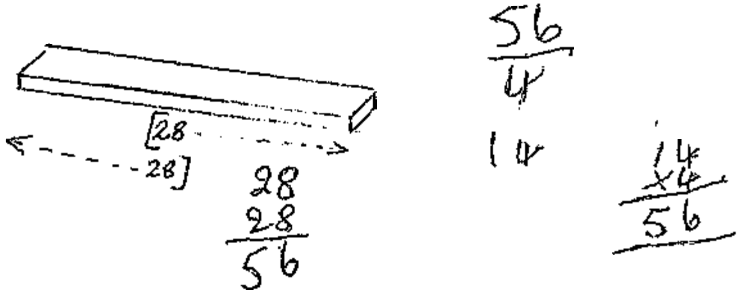
S: This man says he is Thomas and he says he wants to take off a piece four metres long off this ... I think it is a bench ... (subject points to the stool supporting the plank) ... this small plank belongs to this ? ... (pause) ... No ... each must be four metres long and he has a tape under it to measure it ... I think he is wrong because where he cuts is equal to 28 metre and he wants to cut it four metre long not 28 metre ... (silent) ...
I: What is the length of the plank ?
S: From here to here (pointing to each end in turn)? ... or end to middle (subject points from end to centre) ? ... (pause) ... (subject counts the dots showing the length of the plank and seems confused - stops and starts a few times) ... when subject comes to where the dots disappear behind the body of Thomas subject hesitates ... I think its 48.
I: Why ?

Fig 6.19. <u>Convention of showing length using dotted lines</u>



S: Because these small lines (subject point to measurement to the left of Thomas' body) is 4 and when I add them they give me 28 from the end to the middle ... (subject counts the small lines and skips the part hidden behind Thomas' body)
I: Here is the plank (interviewer draws a rectangle on the rough work paper) ... What is the length ?

Fig 6.20. <u>Subject's interpretation of dotted line convention</u>



S: The length is 56 metres (subject has written 28 and under it another 28 and added to get 56)
I: How many pieces can he cut ?
S: (Subject works out on paper and writes 56 then a line under it 4 and then below it writes 14 ... It is 14.
I: Is it correct ?
S: Yes ... (silent) ...
I: Can you check ?
S: (long pause) ... I multiplied the quotient by the divisor and I get 56 (subject has written 14 and under it 4 x and then a line and underneath 56)

Some students did not know how to divide the board into pieces but when they saw the numbers 28 and 4 then the number 7 seemed to be related to these two other numbers and they often said "7" is the answer but did not know if it was 7 pieces or 7 metres. Four students were unable to divide - having decided that long division was the thing to do they started with the units at the right hand side as is correct for multiplication and having written on the rough work paper 28 and under it 4 and a division sign and a line then wrote 2 because 8 divided by 4 is 2, but then they were unable to proceed because 4 would not divide into 2. At this stage some stroked out the 2 and wrote 7 having realised they must divide 28 by 4 starting from the left hand side.

Three students used the wrongly recalled number fact in their strategy saying 28 divided by 4 is 6 and they "proved" they were right by saying 4 x 6 = 28

Japhta Seabe aged 19 years is in 7B at Keledi:

S: (silent for over a minute while eye movement showed studying the picture) ... This picture wants me to multiply ... (silent) ...
I: What is the answer ?
S: 6 times 4
I: What is 6 times 4 ?
S: 28
I: Can you check ?
S: (without speaking takes rough work paper and writes 6 + 6 = 12 etc as shown in Fig 6.21.(a)

Fig 6.21. <u>Solving problem 5 by repeated addition</u>

(a)

6 + 6 = 12 + 6 = 18 + 6 = 24 +

(b)

$$\overset{52}{}$$
$$7\ 4 \times 4 = 16 + 8 = 24 + 4 = 28$$

I: What is the answer ?
S: 6
I: Why ?
S: Because 6 times 4 is 28
I: (pointing to where subject has written 24) What did you write here ?
S: (strokes out 24 and writes 28) no ... 24 ... (whispers) no ... 28 (subject starts writing again as shown in Fig 6.21.(b)
I: What is the answer ?
S: 28
I: What is the question ?
S: (reads aloud in English) How many 4m pieces can Thomas get ? The answer is 8 pieces ...
I: Why 8 ?
S: Because 8 multiplied by 4 is 28

This subject was scored 0 points for problem number 5 and given E symbol. There was quite a bit of confusion about the proper use of terms like "from" in place of "into" and "I multiply 4 by 28 and it gives me 7".

6.6.3. Strategies used in problem number 5

The strategies used in problem number 5 show different levels of abstraction. At one extreme, regarded as the highest level was (i) recalled number fact, then (ii) the so-called derived number fact and at the lowest level of abstraction, (iii) repeated addition. In the analysis of the performance of the students in this problem what is understood by recalled number fact is: either $28 \div 4 = 7$ or $4 \times 7 = 28$. What is meant by derived number fact is the manner some students tackled this problem by using previously learned knowledge about multiples of 4 e.g. they knew $5 \times 4 = 20$ and $2 \times 4 = 8$ and that $20 + 8 = 28$ and from all this they derived the answer which was $5 + 2 = 7$. Not all who are classified in this group used the same technique - some remembered that $4 \times 4 = 16$ and worked from that and still others used $4 \times 6 = 24$. By repeated addition in this problem is meant the way some students added $4 + 4 = 8$ and then added another 4 and so on until they had arrived at 28 and then they counted how many fours they had added together to reach 28 and this was the answer. Of course those students unable to determine any answer were working at a lower level still and presumably if they were presented with 28 counters they would be able to sort them into bundles of 4.

From this table it seems what distinguishes the good and the poor maths students is the former are able to make use of some strategy to find an answer and the latter are not.

Table 6.8. Numbers of students using the strategies

STRATEGY	STUDENTS GOOD AT MATHS	STUDENTS POOR AT MATHS
(i) Recalled number fact	28	3
(ii) Derived number fact	3	2
(iii) Repeated addition	6	4
(iv) Unable to work the problem	0	10

6.6.4. Comparison between good and poor maths students

From Table 6.9. it can be seen that Matale students performed better than either of the other two schools in problem number 5.

Table 6.9. Scores for picture problems for each school

SCHOOL	SYMBOL					TOTAL
	A	B	C	D	E	
Keledi	11	4	7	4	6	32
Matale	14	1	0	0	1	16
Mafenya	7	0	1	1	3	12
TOTALS	32	5	8	5	10	60

The good maths student understood the picture and realised the 28 m plank had to be cut into 4 m pieces. He did not delay in describing the picture but was able to identify the important (in this case the relevant) material from what he was given and then went directly to the question at the bottom of the card. He knew the operation required to find the answer was division and he was able to recall correctly $28 \div 4 = 7$ and that this could be checked by using the inverse operation i.e. $7 \times 4 = 28$. Finally the good maths student could do all this in less than 4 minutes.

In contrast the poor maths students had difficulty in understanding the picture - often they did not know if the plank was 28 m or 56 m and they were unsure if the boy was cutting the plank in half or into 4 metre pieces. The typical poor maths student spent a lot of time describing the picture in detail - it seemed he had difficulty in deciding what was important and what wasn't and in some cases even the window above the boy's head and the stool supporting the plank were sources of puzzlement since the poor maths student couldn't decide if they were or were not relevant to solving the problem. Generally he did not go to the question at the bottom of the card by himself and had to be asked by the interviewer to read the question and sometimes this was not enough and he would remain silent and not attempt to answer the question until the interviewer asked him what was the answer. The poor maths student didn't know what operation to use and had to be helped by the interviewer. He could seldom recall the number fact $28 \div 4 = 7$ and generally used a strategy of repeated subtraction and he had no idea how to check his answer except to repeat the same process again. Finally he took more than eight minutes to come up with a reasonable solution to the problem.

In summary the findings for the picture problem number 5 were as follows:

Good students used recalled number fact $28 \div 4 = 7$. Poor ones sometimes used an incorrect number fact $28 \div 4 = 6$ and once they said 6 it was difficult if not impossible to change their answer - occasionally under pressure from the interviewer they gave another answer but if the opportunity presented itself reverted to their original answer.

Good students were able to abstract the given information quickly from the picture and deal with the numbers $28 \div 4$. Poor students had a lot of trouble with the picture, for example some

- thought the plank was 56 m long
- thought the boy wished to cut the plank in half
- thought the boy wanted 4 pieces instead of four metre pieces
- thought the dotted line showing the plank to be 28m represented intervals of same sort

- were puzzled by the picture and unable to abstract relevant information.

Good students were able to divide in their heads or use derived number facts eg. 4 x 5 = 20, 4 x 2 = 28, 20 + 8 = 28. Poor students used long division and started wrongly with the units eg. right to left as must be done when multiplying but in division should start left to right.

6.7. CONCLUSION

6.7.1. Difficulties

There were difficulties experienced by the subjects and others experienced by the interviewer. First the problems which the interviewer had were due to the real school situation in which the interviews were carried out. Teachers were working, students were taken from class and brought off by the interviewer in a car for several hours, and when they arrived at the local high school some of them thought they were being tested for admission for the coming year. To put it very mildly the research was not carried out in what could remotely be called a clinical situation. The environment could not be properly controlled and even interruptions during the interviews could not be prevented completely. On one occasion - during an interview there were five interruptions ranging from telephone calls, to a lady selling sheets, to a teacher borrowing keys of the interviewer's car to bring a sick student to the clinic. On some occasions arrangements which had been made with the schools to have some students available for interview had to be abandoned but, as anyone who has worked with the Tswana knows, they are very courteous people and the teachers and students could not have been more obliging throughout this research.

The difficulties experienced by the subjects can be listed as:

a) perception of 2-d drawings inadequate. There were in all 59 cases of perceptual problems identified in this research. Altogether 300 cases were studied i.e. 5 each for 60 students. Thus almost 20% of the cases had inadequate perception of 2-d drawings. It must be remembered that all the students interviewed had been graded by their teachers as "average or above average" in maths ability.

b) Students don't know their "tables" well and make many mistakes in the recalling of number facts: sometimes they have to fall back on a cumbersome strategy to work multiplication and division. There were only 31 cases of correctly recalled number facts out of the possible 300 i.e. a mere 10%.

c) Inability to abstract, many are limited to the concrete.

d) Not able to identify properly what information is given the problem.

e) Some don't seem able to see the problems as questions that require some manipulation of numbers.

f) Reliance on authority of the teachers for checking answers.

g) Take a long time in getting to what they are required to do in a given problem.

h) Overhasty decision about which operation to use before fully comprehending the given data.

There must also have been difficulties which the subjects felt within themselves, but the interviewer was not able to g t any information on this even though each subject was asked at the end of the interview how he or she felt about it. Invariably the only reply was to the effect that they enjoyed it very much and that they had learned a great deal from it.

7.7.2. Assumptions

In section 6.1.2. certain assumptions are listed and those dealing with (i) fluency in English (ii) reflective ability (iii) rapport and (iv) suitability of recording method; did not, as far as could be ascertained by the researcher interfere with the interviews. Regarding the other three assumptions the following corrections must now be recorded;

(v) silence on the part of a subject means not knowing the answer; this was true in a number of instances where subjects actually admitted this when the interviewer pressed them to reply after a silence; but this was not always true and when some subjects remained silent after being asked a question it meant they were thinking about the question and weighing up mentally the possible answers.

(vi) the effect of friendly and shy personality on the interaction between subject and interviewer became obvious after the first few sessions. Once the interviewer became aware of it he tried to control facial expression, nodding or any other gestures which might assist the subject

(vii) the picture would assist in the understanding of the problem was the last of the assumptions set out at the beginning of this chapter. What emerged from the interviews does not support this claim for the reasons set out here:

The pictures clearly introduced a new difficulty for some students. This may be understood in terms of Skemp (1979 p.123) who discusses the effect of "noise" in the learning of concepts. Another approach is that of Witkin (1971; E.F.T.) who discusses the disembedding process which is required to extract the relevant information from a given situation.

As a result of the present research it has become clear that four levels of abstraction exist in the presentation of a simple number problem that standard 7 students encounter and are expected to manage in their school mathematics. The four levels are:

level 1: concrete objects which may be regarded as the real life situation - all the information is visible to the subject;

level 2: pictures or drawings are used to represent the concrete and not all the information is visible;

level 3: the concrete situation is described in words;

level 4: only numbers are used.

This hierarchy can only be offered tentatively, but the four levels also correspond to the steps through which a person normally progresses in dealing with the world. First there is a real life situation which is encountered and demands a response; second the person must form a mental image of the situation; third the person must disembed what is relevant and this is done mentally using words; fourth the person abstracts numbers and determines which way to manipulate these numbers in order to find an answer.

6.7.3. Summary

In the analysis of the five problems presented in this chapter it emerges that the major difference between the successful and the unsuccessful mathematics students is in the level of abstraction at which they can and do function. The successful group have gone through the various steps which then enable them to move quickly to the highest level, namely that of number and carry out whatever operation is required.

The successful group have learned how to analyse a given situation and they are able to perceive what it is in that situation that they need to attend to in order to achieve their goal. This goal is set by someone else in the case of most mathematics questions they meet in school. In real life however the goal too must often be set by themselves.

Having successfully established what information they need the successful group are then able to make a mental image and formulate words in order to think about what they must do to find a solution. In the case of the five problems which were used in this research they merely had to decide which arithmetic operation was appropriate. Lastly using numbers only the successful students were able to recall a number fact to find an answer.

The unsuccessful mathematics students were found not to be able to work their way through the levels of abstraction described in 6.7.2. They could be blocked at any one level but the lower the level at which the block occured the worse was their performance in these five problems.

Those who were able to visualise and form mental pictures could generally be helped through the other steps and eventually to work out an answer for themselves. It seems that many of this group however have not been trained in school to move along the levels of abstraction; they seem, judging from their behaviour in the interviews to have got used to either being forced at a pace faster than they can manage or else they are used to being given an answer by the teacher or by one of their companions and agreeing with it without knowing why. Another habit which this group seemed to have developed is leaving the thinking i.e. level 2 and level 3, to someone else knowing that eventually they will be transported to level four and only be required to carry out the number manipulation to find the required answer. That fairly large group of students who have difficulties with the 2-d drawings are being hindered from working problems because of incorrect or inadequate perception of the drawings. It seems a fairly easy matter - once this problem is diagnosed - to teach the basics of correct 2-d perception.

Those students who are unable to visualise and cannot imagine anything other than what they see before them cannot really be said to be ready for standard 7 mathematics and they are in dire need of remedial teaching. This would not be too serious a problem for the schools were it not for the fact that only "good" and "average" maths students were interviewed in this research and there is a whole section of each class in each school which was considered by the mathematics teacher to be "bad maths students" and estimated by this researcher to be about 30% of each class. Undoubtedly the gross over-crowding in some classes has created an impossible situation for the teachers and the reduction of numbers per class and the provision of extra classrooms must be a priority for these schools.

CHAPTER 7

HOME VARIABLES

7.1. Introduction

7.1.1. Criteria of success

In chapter 2 the criteria of success in mathematics used in this research were given as follows:

(i) mathematics mark in June 1987 examination (total population);

(ii) performance in the picture problems (10% sample).

During the pilot study reported in chapter 4 it was discovered that the use of the maths mark presented a difficulty in the sense that these maths marks are so low as to be almost meaningless for the purpose of statistical analysis. However the averages, standard deviations and linear correlation coefficients have been calculated for the total population and are presented later. In chapter 6 was reported how the 10% sample performed in each of the five picture problems. From this performance an average score was calculated and the two groups were distinguished. One group, "good at maths", consists of those who had an average score of 70% or more in the five picture problems; there were fifteen in this group. The other group, "not good at maths", was made up of those whose average score in the picture problems was less than 50%.

The question posed in this chapter is: Are there variables associated with the students' home background which can help to explain the different performance of those students who are "good at maths" and those who are "not good", success being defined separately on the basis of the two criteria given above?

7.1.2. Home variables

Based on the literature a great number of variables has been studied in relation to school achievement. Over 70 are reported by Schiefelbein & Simmons (1978) and in one research study carried out by Carnay & Thias (1974) about 80 variables were tested (Alexander & Simmons 1975 P.21). These researchers divide the variables into three major blocks, usually those variables associated with home background, pupil characteristics and school variables. Each of the three groups of variables were investigated in the present research and are reported in the following chapters thus:

Chapter 7 - Home variables

Chapter 8 - School variables

Chapter 9 - Pupil characteristics

Most of the research studies on achievement in third world countries include socioeconomic status as one of the variables and several have also investigated "modernity" e.g. Holsinger (1973) as well as Carnay & Thias (1974) as reported by Alexander and Simmons (1975 P.61 and P.21 resp.).

It was therefore decided to limit the home variables to:

(i) socioeconomic status (S.E.S.)

(ii) Degree of Westernization

The first of these, namely, S.E.S. requires no justification for being included in this kind of research and the general content of material considered appropriate is fairly well agreed upon in the literature referred to later. Such items as parents' education, income etc. can be combined to make an overall score on a scale. The present research is not a cross-cultural one but is confined to the Bafokeng region of Bophuthatswana. There are two implications from this: One, it was necessary to devise an instrument to measure S.E.S. among the Bafokeng and two, it does not matter whether or not this instrument has applicability outside of this area because what is required of it is to compare "good" maths students with "poor" maths students on socioeconomic measures within Bafokeng. S.E.S. is discussed below in section 7.2.

The second home variable is cultural belief. In trying to understand the different performance of students in mathematics in the light of the discussion about the nature of mathematics and what is meant by "success" in chapter 2, it seemed necessary to explore the degree of westernization among the students being studied. For the Bafokeng mathematics is an imported way of looking at the world.

As it is taught in the local schools it is not based on the Tswana traditions or language or way of organising their thinking, it is a western mode of thinking. Hence it was hypothesised that the degree of westernization would be positively correlated with performance in mathematics. It was decided an instrument measuring cultural beliefs would be the most satisfactory method of classifying students on degree of westernization. Nothing of that nature could be found in the literature and hence an instrument had to be designed to measure and set up a scale for this. McClelland (1961) and (1975) provides a basis for studying national character based on customs practised among the people and Kiely (1983) has applied this method to the Tswana people. The instrument used in this part of the research is based on that work and is described below in section 7.3.

7.1.3. Validity

Both of the home variables which are the subject of this chapter are expressed in quantitative terms and reliability and validity are dealt with here also.
Research is a systematic attempt to provide answers to questions and basic research is concerned with the relationship between two or more variables. In the classical experimental design the researcher attemps to control the environment in such a manner that the

relationship between the given variables can be isolated from other variables and assessed, and a stated hypothesis accepted or rejected. This process of control contributes to what most authors call "internal validity" (e.g. Cohen and Manion, <1980>, Tuckman <1972>). By internal validity is meant that what is studied is in fact producing the outcomes attained (Tuckman 1972, P.4). At the same time such control of the environment simultaneously decreases the so called "external validity". In other words the greater the control of the environment the less the probability that the conclusions will hold in the real world where no experimental manipulations are carried out (ibid).

In chapter 5 (section 5.2.) the design for the present research was described as being an anthropological, non-experimental, descriptive, field study aimed at understanding how the Tswana learn mathematics. There is no attempt to control or manipulate variables and no quantitative measure of internal validity is required. This is not to say that the research here undertaken lays no claim to validity - it certainly does claim such validity as was discussed in chapter 5 where Kelinger's (1986) definition of validity in terms of truthfulness was quoted.

Three steps were taken to ensure validity of the measurement of the home variables:

(i) Each instrument was based on work done by other researchers in the same or related fields of study.

(ii) Data were collected from several sources - from the students themselves, from their teachers and from their friends.

Furthermore the students were asked to complete both the closed ended questionnaire as well as to answer open ended questions. Finally a 10% sample was interviewed to obtain information on their home, family and beliefs. All this was done as part of the triangulation process.

(iii) Scoring of answers in the questionaires was done only after lengthly discussions with a team of scorers composed of the researcher with two others as follows: S.E.S. - G. Boswell, B.A. (Cur) Sister tutor at Bafokeng Nursing College and G. Mompei, B.A. (Hons) Registrar at Tlhabane College of Education.

Cultural Beliefs: A. Segodi, B.A. (Hist) Principal of Bafokeng High School and R. Khutsoane, B.A. (Psych) Principal H.F. Tlou High School.

7.1.4. <u>Reliability</u>

Reliability refers to the consistency with which an instrument produces equivalent scores when administered twice to the same subject or when administered to two subjects of equivalent talent and experience (Cates, 1985 P.124, Bailey 1978 P.73, Tuckman 1972 P.160). In this section the reliability of the instruments measuring S.E.S. and Cultural beliefs, is discussed.

Tuckman (1972, P.161) gives four approaches for determining reliability: test-retest, alternate forms, split-halves and an expansion of the split-halves using the Kuder-Richardson formula. In mathematical terms these are expressed as coefficients of reliability and Cates (1985) gives formulae for calculating these coefficients. In this research two measures of reliability were used for both instruments namely (i) inter-rater reliability and (ii) consistency of response behaviour. By inter-rater reliability is meant the degree with which the three raters agreed on the scoring of responses. The figures for each instrument are given below in the appropriate sections.

By consistency of response behaviour is meant the degree to which the subject is consistent in responding to similar or identical questions. This was done by repeating items in the questionnaires, e.g. I like doing maths homework (as item number 2) and I don't like doing maths homework (as item number 32). This method is often criticised in the literature but it has been used in the case of unsophisticated subjects and it was deemed appropriate for the present research.

7.2. Socioeconomic status

7.2.1. Introduction

In chapter 4 (section 4.2.) reference was made to the analysis done by Schiefelbein and Simmons (1978) on factors related to school achievement in educational research carried out in third world countries. They reported that socioeconomic status, including parents' occupation, income and education, were found to be significantly relat to student achievement in schools. This finding is also supported by the work of Murphree and associates (1975) in Rhodesia* and Auerbach (1978) in South Africa. Many others have investigated the effect of socio-economic factors on learning of mathematics (e.g. Ginsburg and Russell (1981), Fuson and Hall (1983)). Hughes (1981) found that at age 3,5 years children from better-off families were already a full year ahead of working class families in their level of development of the concept "number". Although S.E.S. was not tested in the pilot study it was included in the main field work because of these reasons.

So the purpose of the present exploration of S.E.S. is two-fold:

(i) to investigate if there are significant correlations between S.E.S. scores and success in maths using the two criteria for success separately, as discussed in section 7.1.1. above;

(ii) to try to understand the extent and the nature of the relation between S.E.S. and performance in mathematics for std. 7 students for the Bafokeng region.

* Rhodesia changed its name to Zimbabwe at a later date.

7.2.2. S.E.S. Instrument

Rosier proposes that a composite index of socio-economic level could be constructed from fathers' occupation, parents' education and various measures of material resources (1978, P.60). The home factors used by Auerbach (1978) to construct a "pupil profile index" to predict the probability of dropping out from school included fathers' and mothers' occupation and education (1978, P.205). Kiely (1983) reports that a survey was carried out by the nurses at Phokeng clinic in 1982 to determine the extent and the causes of malnutrition in the area. Two hundred and fifty young mothers were interviewed over a period of one month and data collected concerning: education and occupation of parents, family income, number of occupants in the house, kind of food eaten, agricultural activities, water sources, latrines and house description. In Bophuthatswana, Lawrence and Roodt (1984) used parents' occupation and education to establish the socio-economic status of pupils in schools in the Mmabatho area.

After studying this material it was decided to focus on five clusters of items relating to:

1) Parents' education - both father and mother
2) Parents' occupation - kind of work done by each
3) House description - type of house, number of rooms, latrine
4) Basics such as fuel, light and water

5) Luxuries such as post office box, radio, newspaper, television.

Other items commonly included such as family income, type of food eaten were omitted after a close study of the questionnaire used by Kiely (1983) to measure S.E.S. among students in Bafokeng High School. It was decided to award 8 points in each of the clusters given above but since the literature placed such emphasis on parents' education an extra 2 points were given for it making a total of 42 points as given in Table 7.1.

Table 7.1. Scoring for each cluster in S.E.S. instrument

Cluster	Items	Score
1)	Parents' education	10
2)	Parents' occupation	8
3)	House description	8
4)	Basics	8
5)	Luxuries	8
	TOTAL SCORE	42

The higher the score the higher the level of socio-economic status of the family. Maximum score was 42 and minimum was 0. The questionnaire used is given in Appendix F. Item 4 asked whether parents were alive or not and Item 7 asked where the parents live. Neither of these was included in the scoring because the scorers could not reach agreement on the marking of these items. Item 22 asked who is the breadwinner of the family and item 23 asked who is paying the school fees. These items also were not scored because a considerable numb of students misinterpreted the questions and gave such answers as "brown bread", "my little brother" and other apparently nonsense answers respectively.

7.2.3. Scoring of answers

The three scorers met together and after considerable debate agreed on the following system of scoring for each cluster.

cluster 1: Parents' education - father and mother scored separately with 5 points each to make a maximum score of 10.

Table 7.2. Scoring for parents' education

STANDARD	Score
10 (matric, final year of high school)	5
8 (old junior certificate)	4
6 (old primary certificate)	3
4 (final year of primary)	2
1, 2, or 3	1
no schooling	0

In the present system of education in Bophuthatswana, standard 4 is the last year of primary school, standard 7 is the last year of middle school and standard 10 is the last year of high school. The system was only introduced in the eighties and most of the parents would have done their schooling under the old system in which primary finished at standard 6 and junior secondary finished at standard 8.

Cluster 2: Parents' occupation - father and mother scored separately with 4 points each.

Table 7.3. <u>Scoring for Parents' Occupation</u>

OCCUPATION	SCORE
<u>PROFESSION</u>: nurse, teacher, supervisor, self-employed as shop owner, taxi owner, witchdoctor etc.	4
<u>WHITE COLLAR</u>: clerk, secretary, cashier, salesman, librarian, security	3
<u>SKILLED</u>: mechanic, driver, carpenter etc.	3
<u>SEMI-SKILLED</u>: mine-worker, bakery, factory, garage worker etc.	2
<u>LABOURER</u>: domestic, garden boy, farm worker, petrol attendant, kitchen girl etc.	1
<u>UNEMPLOYED</u>:	0

This classification was easy in the sense that the list of occupation categories is fairly standard in research of this kind. For example Lawrence and Roodt (1984, P.5) used the same categories in another part of Bophuthatswana. But the difficult part was assigning actual work done by the parents to the various categories. Meanings of terms such as "garage worker", "mechanic", "petrol attendant" are specific to particular kinds of jobs as the local people use such terms.

The criteria used by the scorers in the above classification were:

(i) respect within the community

(ii) salaries earned in that job

(iii) education level required

There were some jobs that did not fulfil all three categories but if two of the three were satisfied then it was regarded as sufficient. A case in point is the work of the "witchdoctor" which was eventually given a score of 4 because of the money earned and the respect of the local community. There was a number of ambiguities in the ans.ers such as "taxi man", this could mean owner = 4 points, or, driver = 3 points; and "builder" could mean brick-layer = 2 points, or, labcurer = 1 point; and "mine-worker" could mean a great variety of jobs from clerical work to shovelling rock underground. In many instances familiarity with the local scene enabled one or other of the scorers to interpret some answers; as for instance, the boy who wrote "mine-worker" for his father who is really the principal of the Mine Nursing College, and therefore was awarded a score of 4 instead of 2.

Table 7.4. <u>Scoring for family house</u>

QUESTION	ANSWER	SCORE
Q.12 Type of house:	brick house	3
	mud hut	2
	tin shack	1
	no house	0
Q.13 Number of rooms:	8 or more rooms	3
	5, 6, or 7 rooms	2
	2, 3, or 4 rooms	1
	just one room or curtain divides	0
Q.16 Kind of latrine:	indoor flush toilet	2
	pit latrine	1
	none	0

Cluster 3: Home in which the family live. There were three items in this category - type of house, number of rooms, kind of latrine. Eight points were scored, 3 each for type of house and number of rooms, and 2 only for latrine because almost all had pit latrines.

Again this classification would not be suitable for other areas. There is no sewage system in Phokeng and almost all houses use a pit latrine. The number of rooms is very large and it reflects the African tradition of having a compound of many small huts used mainly for sleeping; while the cooking, washing and other chores were done outside in the yard ("lapa"). In a few cases even these straightforward questions were not understood by some students as in the case of one girl who claimed her home has 2861 rooms! In all cases where the question was not answered then 0 points were scored for that question.

Cluster 4: Basics for a house. Three items were considered to be basic for any house namely water, light and fuel. Eight points were scored, 3 each for fuel and water; 2 for light, because almost all used candles for light.

There were very few problems with this category. Some students did not properly understand the term "fuel" and thought they were being asked what they used for cooking and answered "sunflower oil" or some such.

Table 7.5. Scoring for fuel, light and water

QUESTION NUMBER	ANSWER	SCORE
Q.14 (Fuel)	Electricity	3
	Coal or Gas Stove	2
	Paraffin/Primus Stove	1
	Wood fire	0
Q.15 (Light)	Electricity/Generator	2
	Gas lamp/Paraffin lamp	1
	Candles	0
Q.17 (Water)	Indoor running water	3
	Own pump	2
	Village pump	1
	River	0

Cluster 5: Luxuries for family. Four items were scored in this category, with two points each, to make a total of 8 points.

There were no disagreements between the scorers about the scoring in this cluster.

Table 7.6. Scoring for luxury items

ITEM	ANSWER	SCORE
Q.18 (P.O. Box)	Yes, and can give the number	2
	Yes, but don't give the number	1
	No, or blank	0
Q.19 (Radio)	Listen, and can name the station	2
	Listen, but can't name the station	1
	Don't listen to radio	0
Q.20 (Newspaper)	Family buys one every day	2
	Family buys one weekly	1
	Don't buy a newspaper	0
Q.21 (Television)	Watch T.V. every day	2
	Watch T.V. sometimes	1
	Don't watch T.V.	0

7.2.4. Validity and Reliability

The instrument was designed to measure socio-economic status of the families of Standard 7 students in the Bafokeng region. The categories were designed specifically for this research by the researcher using sources described earlier. The scoring was done by the researcher, G. Boswell and G. Mompei. Interscorer agreement was 100%. Q.4, Q.5, Q.6 and Q.7 were used to measure consistency of response behaviour.

The number of students who gave self-contradictory responses to these questions was counted and expressed as a percentage of the total number of students.

The validity of the S.E.S. instrument rests on the tri-angulation technique used to collect material from a number of different sources. Three sources were used in this section:

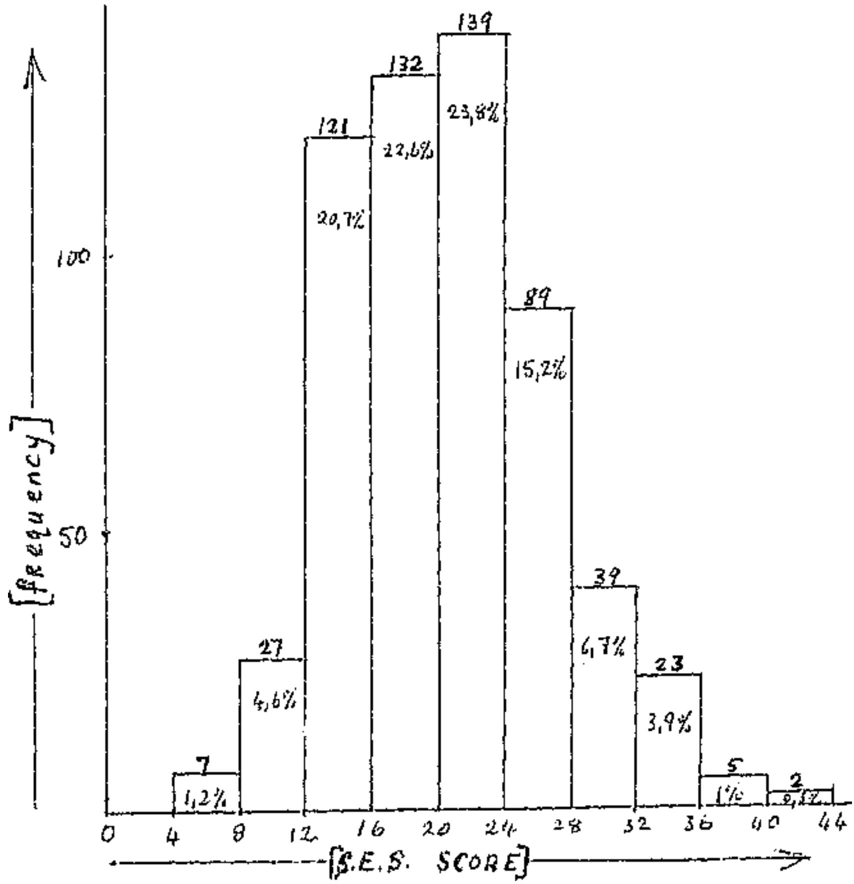
(i) the S.E.S. questionaire as shown in the appendix F

(ii) the interview of the sample of 60 students during which they were asked about their homes and families; at the same time observations were made by the researcher on the quality of clothes, shoes, watches of the interviewees which provided clues as to their economic status.

(iii) the knowledge which the three scorers had individually of certain families - approximately 10% of the population were known to one or other of the scorers and the results on the questionnaires gave a true picture of the S.E.S. of that family in the opinion of the scorers.

is given in Figure 7.1.

Fig. 7.1. Frequency Distribution of S.E.S. scores for the total population.



Only 69 ie. 12% scored 29 or above. When we consider how the scoring was done this shows that the population as a whole could be described as "not well off". Items being scored included house, light, water, electricity, toilets etc and in these items the students' homes are far below what might be expected for a centre like Phokeng on whose tribal lands the richest platinum deposits in the world are mined. In fact it can be stated that the population in general represents third world conditions.

Again for parents level of education and employment the standards are low and the parents of many students have had no schooling and are presumably illiterate. The majority of the mothers who work outside their own homes are employed as domestics or "kitchen girls". A large number of the fathers work as "semi-skilled" (a euphemism for builders mates, petrol attendants, cleaners etc) or, as labourers or "garden boys". There was some difference between the schools on the S.E.S. instrument.

Table 7.8. <u>Average Scores in S.E.S. for each school</u>

SCHOOL	N	AVERAGE SCORE	STANDARD DEVIATION
Keledi	301	19,6	6,2
Matale	157	24,5	6,1
Mafenya	126	20,0	4,6
Total	584	21,0	6,2

The averages are given in Table 7.8. The students at Matale have the highest S.E.S. of the three schools and those at Keledi the lowest. A partial explanation for this is to be found in the geographical location of these two schools as dicussed in chapter 8 and shown in Figure 6.1. of chapter 6. Matale school is in the centre of Phokeng and surrounded by well established families. In contrast Keledi is at the eastern boundary and nearby are the "poor" settlements of Lefaragatle and Bobuantsha whose people are for the larger part not belonging to the Bafokeng and might even be classified as squatters.
The difference between the schools in S.E.S. will be taken up again in the next chapter. The correlation coefficients were calculated using Spearman's correlation coefficient. The coefficients for S.E.S. and maths marks for each school and for the total population are given in Table 7.9. The coefficients for S.E.S. and Interview scores (averaged for the five picture problems) are given in Table 7.10.

Table 7.9. <u>Spearman Correlation Coefficient for maths/S.E.S</u>

SCHOOL	N	r	SIGNIFICANCE
Keledi	301	0,055	none
Matale	157	-0,014	none
Mafenya	126	0,122	none
Total	584	-0,029	none

There is no significant correlation between maths marks and S.E.S. scores obtained from this instrument. This finding runs contrary to previous research in developing countries quoted in chapter 5, section 3.4.5. Schiefelbein and Simmons (1978) found that out of thirteen studies on S.E.S. ten found it a predictor of scholastic achievement.

This finding raises questions about the validity of the measuring instrument for S.E.S. and of course the validity of the maths marks. It has been pointed out in section 7.1. above that the maths marks of the total population are too low (mean mark = 28,6%) and the distribution is so skewed (median mark = 26%) that meaningful analysis for correlation purposes using these marks is questionable. A total of 266 out of the 584 students scored less than 25%. In Bophuthatswana all such marks are given symbol H and are not counted towards a candidate's aggregate mark.

A second set of correlation coefficients was calculated using the picture problem score as the criterion of success at maths.

Table 7.10. <u>Correlation coefficients for picture problem scores/S.E.S.</u>

SCHOOL	N	r	SIGNIFICANCE
Keledi	32	0,4583	$p < 0{,}01$
Matale	16	0,4720	$p < 0{,}05$
Mafenya	12	0,3951	n.s.
Total	60	+0,433	$P < 0{,}01$

Using the criterion of picture problem score a positive correlation significant at the 0,01 level has been established between S.E.S. and success in maths.

Lastly a comparison between those students who scored high in the picture problems and those who scored low was made by calculating averages of their S.E.S. scores and this is given in Table 7.11. The overall average of the group who are good at maths is 26,1 compared to 19,3 for the group who are not good at maths.

Table 7.11. S.E.S. Scores of the two groups on picture problem criterion

SCHOOL	GOOD AT PICTURE PROBLEMS			WEAK AT PICTURE PROBLEMS		
	N	Mean S.E.S. Score	sd	N	Mean S.E.S. Score	sd
Keledi	5	24	6,2	15	18	6,2
Matale	6	32	6,1	0	-	-
Mafenya	4	21	4,6	4	24	4,6
TOTAL	15	26,1	5,7	19	19,3	5,9

The "good at maths" group has a higher S.E.S. average than the "not good at maths" group, except in the case of Mafenya school. The conflict situation described in chapter 8 between the maths teacher and the head of the maths department in this school may be the major contributing factor to this unexpected result which shows a higher S.E.S. score for students who are not good at maths using the picture problem criterion, when compared to students who are good at maths using the same criterion. In spite of this discrepancy there is still a 17% difference overall between the two groups. The higher the S.E.S. score the better chance a student has of doing well in picture problems. The implications of this are discussed in the next section.

7.2.6. Comparison of "good" and "poor" maths performance on S.E.S. scores

When the students who scored A or B on the picture problems were compared to those who scored D or E by taking the average for their S.E.S. scores a mean difference of 6,8 points was noted. The average S.E.S. score for those students who scored high marks in the picture problems was 26,1 whereas those who scored low marks in the picture problems had an average S.E.S. score of 19,3. The S.E.S. score was calculated from parents' education, parents' occupation, and ameneties at the home. The good maths students came from better off families, as indicated by these scores. The results show that the "good at maths" students are economically advantaged when compared to the "poor at maths" students. The influence of better living conditions such as having more space in which to work, better light, better cooking facilities and the possibility of greater stimulation from better educated parents all affect how a student learns in school.

By comparison the students who performed badly in the five picture problems came from poorer and less well educated families. Not only do they suffer from the lack of stimulation provided by newspapers and television, but their parents are less educated they are unable to understand what their children are learning in school.

7.3. Degree of westernization

7.3.1. Introduction

Because of findings in the literature referred to in chapter 4 section 4.6. it was hypothesised that degree of westernization would correlate significantly with mathematics attainment and therefore would shed some light on success and failure in mathematics among the Bafokeng. In the pilot study this was tested for a small sample using performance in the standard 7 mathematics examination as the criterion for success. The results showed a high correlation for the matched groups of girls but not for the boys. It was decided to redesign the instrument in the light of responses in the pilot study and to administer it to the whole population.

7.3.2. Description of instrument

The categories suggested by McClelland (1975) for analysing national character are: child rearing, political behaviour, religion, leisure, work, death, and general. These were used to design the instrument used in the pilot study. When the results were analysed it was decided to redesign the instrument using eleven categories as follows: Tswana name, discipline, religion, leisure, role-identification, death, marriage, child-rearing, domestic work, government, and trivial. Eleven clusters of items were used relating to:

1) Naming of new-born children with a "Tswana name"
2) Control and authority in the home
3) Religion as it refers to traditional medicine and the ancestors (= badimo)
4) Leisure and how students spend their free time
5) Men's role and women's role
6) Customs in relation to funerals and death
7) Practices connected with marriage
8) Child rearing
9) Habits of eating, washing and carrying
10) Government and role of the Kgotla (= local government)
11) Trivial matters like how to walk and about dancing

It was decided to score 1 point for each answer: thus -1 point for what the scorers decided was a traditional Tswana answer, and +1 for what was considered a western style answer. These scores were then adjusted so that the total for each cluster would be the same as shown in Table 7.12. above.

The scores could range from a minimum of -88 which would indicate an extremely traditional Tswana family to a maximum of +88 which would indicate an extremely westernized family.

Table 7.12. Scoring in each category in the degree of westernization questionnaire

CLUSTER	ITEMS	SCORE (MAX/MIN)	ADJUSTMENT FACTORS
1) Tswana name	Q's 1, 3, 5, 7	+4/-4	X2
2) Authority	Q 9	+2/-2	X4
3) Religion	Q's 11, 12, 13, 14	+8/-8	X1
4) Leisure	Q's 15, 16	+2/-2	X4
5) Role Identification	Q's 17, 18	+2/-2	X4
6) Death	Q's 21, 22, 23, 24	+4/-4	X2
7) Marriage	Q's 26, 27	+2/-2	X4
8) Childrearing	Q's 29, 30, 31	+3/-3	X2$\frac{2}{3}$
9) Domestic	Q's 25, 33, 34	+3/-3	X2$\frac{2}{3}$
10) Government	Q 35	+1/-1	X8
11) Trivial	Q's 28, 32	+2/-2	X4

The full questionnaire is given in Appendix E. Items number 2, 4, 6, 8, 10, 19, 20, were not scored because the scorers were unable to agree on what constituted a "traditional" as opposed to "western" response. None of the questions was mis-interpreted; however some students showed lack of consistency in their responses to Q.6 and Q.7 saying on the one hand that everyone <u>should have</u> a Tswana name and then saying they <u>do not wish</u> their own children to have one. Several students also marked two contradictory responses for some of the items numbered

21 to 35.

7.3.3. Scoring of answers

The researcher and the other two scorers agreed on the system of scoring for each cluster as given in Table 7.13 and following.

7.3.3.1. Cluster 1 (Tswana name)

In the Tswana culture the so-called "Tswana name" is a very important tradition and is linked with ancestor worship. In the families the new-born child is named by the parental side and this is the name by which the child will be known. This is not the case with other tribes who name the child from the maternal side. However even with the Tswana the maternal grandparents will often give their own name and use this name when talking to the child. Unless the husband chooses not to exercise his right to name the child after his own side, in which case the maternal grandparents will select the Tswana name, otherwise it is the tradition for the husband's parents to give a name (Appendix A No.6). The name is seen to be effective in linking the child to the ancestors. Most of the names used in the Bafokeng region are very beautiful. Some examples are "Mpho" (Gift), "Tumelo" (Blessing), "Tshepo" (Hope), "Letlhogonolo" (Happiness). Some however are not so uplifting, for example "Matlakala" (Rubbish), "Gadifele"

(Problems). One can only guess at the effect such a name must have on a child.

Table 7.13. Scoring for Cluster 1 (Tswana name)

ITEM	QUESTION	ANSWER		
		-1	0	+1
Q.1	Have a Tswana name?	Yes & give it	Blank	Repeat English name
Q.3	Who gave it?	Grandparents	Don't know	Anyone else
Q.5	Like it?	Yes	Don't know	No
Q.7	Wish it for own children?	Yes	Don't know	No

Table 7.14. Scoring for Cluster 2 (Authority)

ITEM	QUESTION	SCORE FOR ANSWER				
		-2	-1	0	+1	+2
Q.9	What happens when you do wrong?	corporal punish-ment	anger	blank	advice	deprived of pocket money

7.3.3.2. Cluster 2: (Authority)

The traditional way for exercising authority is for the parents to punish the child by beating, although some parents just get angry and shout at the child. It is not the Tswana tradition to talk about the wrong or to discuss it with the child and this is seen to be a western custom which is however more common among certain families nowadays.

Things like withholding pocket money or depriving the child of some treat are seen to be ways of dealing with an offence which some people have learned from the television or from magazines.

7.3.3.3. Cluster 3: (Religion)

The witchdoctor's business is very prevalent in Phokeng when the people seek solutions to problems. A mild form of it is "go bereka lapa" (= to bless the house). In this exercise the witchdoctor visits the home and for a small fee blesses the premises and the children as a sort of protection for example before a child starts going to school. For more serious trouble a traditional ritual is carried out which may include the slaughtering of a beast and ritual cleansing of all the family members. Fewer people do this nowadays because they say they are westernised. Estimates about this are difficult to establish with reliability but the scorers con ider 30% of families in Phokeng still practise at least the mild form of witchdoctor's business. In the researcher's own experience the more drastic rituals have been quoted as reasons for "ritual murder" of children and students in several instances.

Table 7.15. Scoring of questions dealing with religion

ITEM QUESTION	SCORE FOR ANSWERS				
	-2	-1	0	+1	+2
Q.11 Who are the badimo?	Spirits	Dead people	Blank	Don't know	No such thing
Q.12 Consulted witchdoctor?	Often	Yes	Blank	No	Never
Q.13 Power of witchdoctor	Tell about enemies	Can help	Blank	Don't know	Cannot help
Q.14 How family deals with problems?	witch-doctor	Grand-parent Kgotla	Blank	Friends	church Social-worker

7.3.3.4. Cluster 4: (Leisure)

There is a great contrast between students judging from their replies to these questions. One boy says he spends his time working with his father mending wooden fences on the farm, another spends his time playing soccer and watching TV. One girl says she works around the house and another girl says she spends her free time at a disco drinking cool drinks. The former were judged to be "traditional" and the latter "western".

Table 7.16. Scoring on cluster 4 (Leisure activities)

ITEM QUESTION	SCORE GIVEN FOR ANSWERS		
	-1	0	+1
Q.15. How you spend your free time?	Discussion with friends,	Blank	Reading,TV, Play soccer,
Q.16. Favourite singer?	Sitimela,Sank One, who sings traditional	Blank	Brenda Fassi, Chicco, Western style pop singer

7.3.3.5. Cluster 5: (Role identification)

There was disagreement between the researcher and the other two scorers about the scoring for this category. The researcher considered anything which was thought of as "hard work" or work away from the home to be traditional for men, and "easy work" or work about the home to be traditional for women. The scorers disagreed and insisted that only work such as building, cattle herding, fighting and hunting were traditional for men and only work in the home was traditional for women. They considered all forms of professional work, like nursing, teaching, shop keeping, clerical work, etc to be non-traditional and that was adopted for the scoring of Q.17 and Q.18. A score of -1 was given for "traditional work"; and +1 for "non-traditional", and 0 was scored whenever the question was not answered.

7.3.3.6. <u>Clusters 6: to 11:</u>

Death, Marriage, Childrearing, Domestic, Government and Trivial were presented on the questionnaire in the form of fixed responses where the students selected a response: -1 (it is good); 0 (don't know), +1 (it is old-fashioned) as shown in Appendix E. The items were given in the form of statements of customs which are common in Phokeng.

7.3.4. <u>Validity and Reliability</u>

This instrument was designed to measure cultural beliefs in order to establish the degree of we.ternization of the students' families.

The scoring was done by the researcher, with A. Segodi and R. Khutsoane both local high school principals. Only items on whic, the scorers could agree distinguished between traditional and non-traditional were included in the final scoring. The inter-scorer agreement 100%. The consistency of responses was based on replies to Q.6 and Q.7 together with Q.21 to Q.35. If a student was self-contradictory in any of these items it was taken as unreliable and calculated as a percentage as given in Table 7.17.

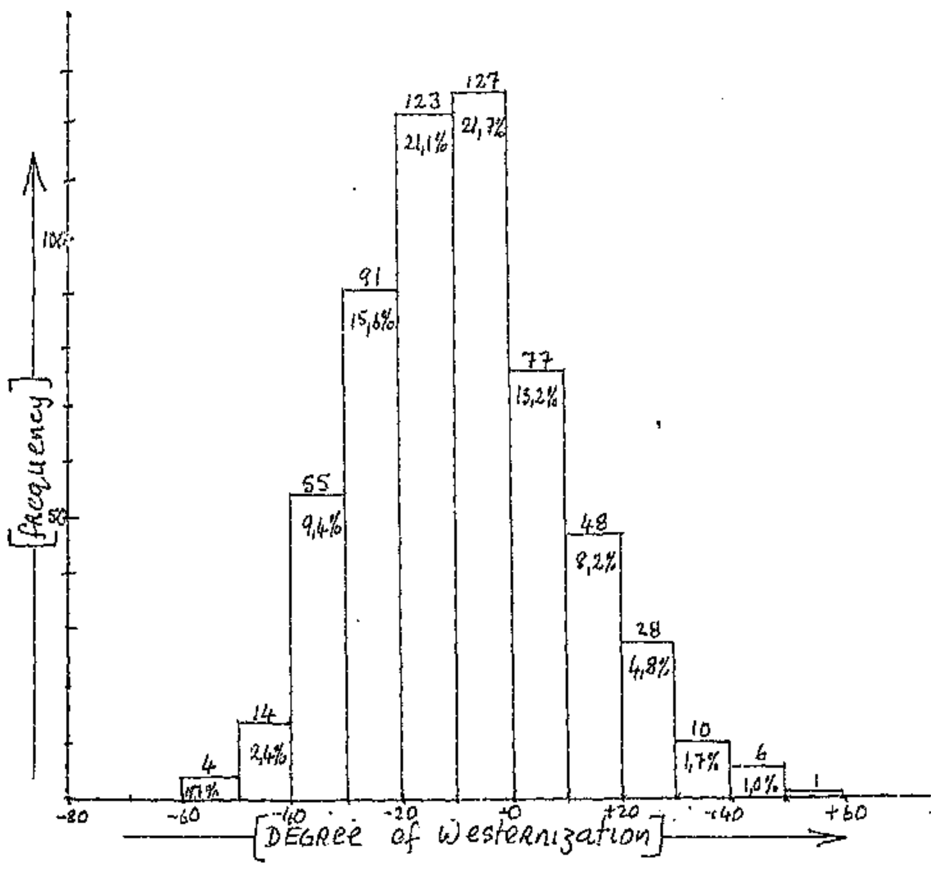
Table 7.17. Consistency of responses for degree of westernization instrument

SCHOOL	CLASS	NUMBER OF RESPONSES	SELF-CONTRADICTORY RESPONSES	PERCENTAGE CONSISTENCY
Keledi	7A	79	7	91%
	7B	73	13	82%
	7C	78	12	85%
	7D	74	6	92%
Matale	7A	39	3	92%
	7B	47	7	85%
	7C	28	1	96%
	7D	40	0	100%
Mafenya	7A	44	6	86%
	7B	43	12	72%
	7C	39	10	74%
TOTAL		584	77	87%

7.3.5. Results of the degree of westernization questionnaire

Altogether 584 students answered the questions on degree of westernization although not all answered every question. The scores range from -54 to +56 while 43% of the scores lie between 0 and 20. Most of the students have negative scores - in all 414 out of the 584 replies, which is 71%.

Figure 7.2. <u>Frequency distribution of degree of westernization scores</u>



A negative score indicates a traditional Tswana set of cultural beliefs. A much smaller number obtained positive scores on this test - in all 170 students, which represents 29% of all those who answered. Positive scores indicate a greater degree of westernization. This shows there are considerable cultural differences within the population and that while the society is in a state of transition from "traditional" to "modern" the old customs and beliefs are still deeply embedded in the people. The frequency distribution is given in Figure 7.2.

The averages for each school and for the total population are given in Table 7.18.

Table 7.18. <u>Averages and standard deviations for degree of westernization</u>

SCHOOL	N	AVERAGE SCORE	STANDARD DEVIATION
Keledi	301	-9,7	18,1
Matale	157	-6,9	19,6
Mafenya	126	-9,3	21,1
Total Population	584	-8,9	19,2

In this test, just as in the S.E.S. Matale and Keledi schools are most unlike. Keledi has the most negative average i.e. students are more traditionally Tswana than the others. It will be recalled that in 7.2.5. above, it was shown that Matale had the highest S.E.S. average scores and Keledi the lowest. Using the modified formula for standard error of difference given by Allan (1982 P.141) the mean scores given in Table 7.18 are not statistically significant at 5% level, and no other correlations can be drawn from these figures. Spearman's correlation coefficient was calculated for the degree of westernization scores using separately the criterion of maths mark and the criterion of average scores obtained in the five picture problems. These coefficients are given in Table 7.19 and Table 7.20 respectively.

Table 7.19. <u>Spearman correlation coefficients for maths/westernization</u>

SCHOOL	N	r	SIGNIFICANCE
Keledi	301	-0,072	none
Matale	157	-0,001	none
Mafenya	126	+0,070	none
TOTAL	584	+0,005	none

Table 7.20. Spearman correlation coefficients for picture problem scores/westernization

SCHOOL	N	r	SIGNIFICANCE
Keledi	32	0,4954	$p < 0,01$
Matale	16	0,5023	$p < 0,05$
Mafenya	12	0,3794	n.s.
TOTAL	60	+0,4979	$P < 0,01$

There is a correlation (significant at the 0,01 level) between degree of westernization scores and picture problem scores.

When the two groups of "good at maths" and "not good at maths" students were compared using their respective scores on the degree of westernization test a clear distinction emerged. Those who were good at maths scored +9,1 average which is well to the right of the neutral point and shows they are more westernized than other members of total population for which the average was -8,9 as shown in Fig 7.3. Those who were not good at maths on the other hand, averaged well to the left of the neutral point with an average score of -16,8 showing they are more traditional than the average of the population and very much more traditional than the group of good maths students. The figures are given in Table

7.21.

Table 7.21. <u>Average Scores of "good" and "not good at maths" on degree of westernization</u>

SCHOOL	GOOD MATHS STUDENTS			NOT GOOD MATHS STUDENTS		
	N	Total westernization Score	Average	N	Total Westernization Score	Average
Keledi	5	+27	+5,4	15	-253	-16,9
Matale	6	+68	+11,3	0	-	-
Mafenya	4	+42	+10,5	4	-66	-16,5
Total Population	15	+137	+9,1	19	-319	-16,8

The difference between the two groups on the degree of westernization scores is statistically significant at the 1% level. Although Mafenya students differed from Keledi and Matale in their S.E.S. scores they followed the same pattern as the other two schools in their degree of westernization scores. The "good at maths" students from all three schools are more westernized than the "not good at maths" students.

The degree of westernization scores for the two groups of students who (i) scored A or B (i.e. 7 or above) in the picture problems and who (ii) scored D or E (i.e. 4 or below) in the picture problems were compared using the chi squared test.

Positive scores (= westernized) were taken as high scores and negative scores (= traditional Tswana) were taken as low scores for the two groups.

Since the expected frequencies were less than 10 in three of the cells,Olls Yates's correction as given by Levin (1973 P.194) was applied. The result yielded χ^2 = 11,4 which is significant at 1% level ($p < 0,01$).

7.3.6. Comparison of "good" and "poor" maths performance using culture scores

The scores of the 15 students scoring A or B on the picture problems were totalled and averaged and the same was done for the 19 students scoring D or E. These figures are given in table 7.22.

Table 7.22. Average of culture scores

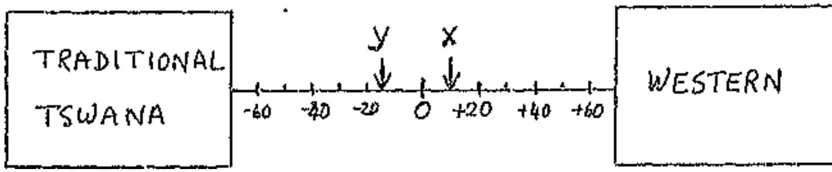
MATHS PERFORMANCE	SYMBOLS	N	TOTAL SCORE	AVERAGE
"good"	A or B	15	+137	+9,1
"poor"	D or E	19	-319	-16,8

From this table it can be seen that there is a considerable difference between the two groups when compared on their scores obtained in this questionnaire.

The degree of westernization was being measured in this section. The maximum positive score was +88 which would indicate a non-traditional and more western set of cultural beliefs. The minimum negative score was -88 which would show an opposite set of beliefs, described here as traditional Tswana. The chi squared value for correlation between degree of westernization and picture problem scores was 14,0 for N = 34 df = 1. This figure is significant at the 0,01 level.

This figure shows that the "good at maths" students are situated to the right of the neutral point represented by zero and they are more westernized when compared with the "poor at maths" students. The latter are situated to the left of the neutral point and are more traditionally Tswana in their beliefs.

Figure 7.3. <u>The continuum of cultural beliefs</u>



Point X on this line shows the position of the "good at maths" students. Point Y shows the position of the "poor at maths" students. It was decided at this stage that the investigation had to be deepened in order to understand why students with good maths performance in the picture problems were more westernized than those who performed poorly in the picture problems. This is done in 7.4. below.

7.4. Relationship between culture and performance in mathematics

7.4.1. Introduction

It has been established above in section 7.3. that culture as measured by the degree of westernization instrument is significantly related to mathematical performance. The question now arises as to what is the nature of this relationship. The methodology of this research is illuminative and pursuing this line of research it was necessary at this stage to return to the literature in order to find guidelines for deepening the investigation. Two major lines of approach were thus uncovered as to how culture might affect mathematics performance: (a) language and (b) perception.

In the analysis presented here these two aspects of Tswana culture were further investigated. In the section on language Setswana was first examined for words used to name mathematical concepts and secondly the use of Setswana by students and teachers when studying mathematics was looked at. The results of this investigation into how language may affect mathematics performance is given in 7.4.2. and perception is dealt with in 7.4.3.

7.4.2. <u>Language</u>

Language is sometimes thought of simply in terms of its communicative function between individuals but Skemp (1979) among others reminds us that w . has to be communicated must first be brought to conciousness in reflective thought and for this we need not just a collection of words but a language. (Skemp 1979 p.159). Bernstein has carried out some deep investigations into the functions of language which he claims include: regulative, instructional, inter-personal and imaginative (1971, P.15). He was concerned with the sociology of language and he conceptualised the functions in terms of critical primary socializing contexts. He used the term "code" for the regulative principle which controls the form of the language (*ibid*). Some of the literature concerning language has been reviewed in section 4.7. as part of the pilot study. In the present section only the influence of language on mathematics will be dea with.

7.4.2.1. Literature

In order to understand the connection between language and performance in mathematics it was necessary to return to the literature and to look at what other researchers had found.

In a study on Zulu children, Guma (1982, p.3) notes that language is a problem for educators in South Africa because of the overcrowded language curriculum in the schools where three official languages must be taught. The constricting effect of this requirement was recognised in Bophuthatswana where the national Education Commission of 1978 recommended that only two languages be compulsory (p.72 Art. 2.1.). Over ten years later the common practice in the high schools is still 50% of class time given to language teaching. In the middle schools it is a little less and varies somewhat from school to school. But time spent at Tswana, Afrikaans and English takes up not less than 40% of class teaching time.

In spite of the considerable time spent on language, certain researchers such as Guma (1982, p.7) and Michau (1978, p.22) can still claim that most African students, and Zulu children in particular, perform poorly in school due to lack of language proficiency. Visser and other writers in Matlhasedi - the education bulletin of UNIBO - state unequivocally that a poor mathematics reading ability is one of the biggest drawbacks to success in mathematics in Bophuthatswana (1988, Vol.7, p.28).

It would not be true to say, however that there is general agreement in the literature that the use of more than one language in school is altogether bad educationally. Diaz (1982) reviews the research into the impact of bilingualism on cognitive development. He lists the beliefs that have arisen either through popular notions or based on poorly designed research that failed to control for confounding variables such as actual knowledge of language or S.E.S. status. Diaz lists these beliefs thus:

> that children who are instructed bilingually from an early age will suffer cognitive or intellectual retardation in comparison with their monolingually instructed counterparts; they will not achieve the same level of content mastery or acceptable language skills; the majority will become anomic individuals without affiliation to either ethnolinguistic group (Diaz 1982 p.25).

Diaz further claims that in the literature there is considerable support for the opposite view that instead of hindering, bilingualism actually promotes cognitive performance and that children's bilingualism is related to positive cognitive gains.

One of the most active workers in the study of the effects of bilingualism was John Macnamara. He reviewed 22 studies in which attainment in arithmetic which involved computation only was researched (1967, p.74). Macnamara had done his doctoral research on bilingual problems in Irish schools and he clarified the concept "bilingual" by distinguishing between the relative ability of children in each language. In Ireland, for instance, most of the children use English in their homes but the medium of instruction in schools is often Irish. Macnamara suggests that English is the "stronger" language and Irish the "weaker" language in this case. The same situation obtains in Bophuthatswana where Setswana is the stronger language because it is the home language and the preferred language for communication in the playground among the students and in the staff room among the teachers. But inside the classroom the medium of instruction is English which must be regarded as the weaker language in this situation. Prior to 1976, schools had no choice in the matter of medium of instruction and the official regulations required that half of the instruction be given in the medium of Afrikaans and half in English. After the school riots in Soweto and elsewhere this regulation was removed and schools are now free to choose either English or Afrikaans as the medium of instruction.

In Bophuthatswana the National Education Commission of 1978 decided to use English as the medium for all schools from standard 3 upwards (p.51, Art 5.2.). Macnamara (1967, p.125) reports that his own research findings show that the problem-solving ability of bilingual children is poorer when information is supplied in their weaker language even though the components of the problem are separately understood. As already pointed out in chapter 4 section 4.7. other researchers used different classification systems from that of Macnamara. Thus Ferguson (1959) referred to H and L language types. H signified language associated with high culture and was usually used with religion, education and other aspects of high culture. L on the other hand referred to language used mainly in conjunction with everyday pursuits - the so-called low culture (Serpell 1976, p.639). Serpell adds that L code is what a child first learns at home and only at school does he learn the H code. This observation led Young (1977) to use the terms "village knowledge" and "school knowledge". In the case where the school medium is a second language then a tremendously complex situation arises and there is often an enstrangement between the culture of a child's home and what he learns at school (Serpell 1976, p.64). Siann and Ugwuegbu (1980, p.208) put forward the hypothesis that one serious result of the language confusion is the creation of two seperate realms of knowledge. They used the terms coined by Young (1977, p.25) quoted above:-

(i) "village knowledge" which covered things like family and traditional occupations about the home

(ii) "school knowledge" which concerned arithmetic, science and how people lived in other countries

Young (1977) found his subjects were favourably disposed to the type of knowledge typical of schools because it enabled people who gained it to be free of the constraints of locality, tradition and village life. This favourable attitude to mathematics, because it held the key to freedom from drudgery and hard physical work, was also found in the present research among the standard 7 students in the Bafokeng region. From 584 repl s to the question: why do you wish to study maths? 374 gave reasons associated with good jobs, easy work and future careers.

Another interesting claim made by Si..n and Ugwuegbu (1980) is that school knowledge is based on "disembedded thinking" which can be measured by an embedded figures test as described in chapter 3, section 3.2.5.. Donaldson (1978) suggested that children from homes where such a style of thinking is encouraged are given a good preparation for the cognitive and learning tasks of school (Donaldson, 1978 p.24). This latter point sheds some light on the relationships found in the present research and presented in 7.2. and 7.:.3. of this chapter. Both socioeconomic status and degree of westernization had positive correlations with mathematics performance in the picture problems. These findings may now be understood better when it is realised that cognitive style promoted in homes of better-off children with higher S.E.S. scores than the average, predisposed these children to be receptive to school knowledge. On the other hand, children from low S.E.S. groups are disadvantaged because their parents have little or no understanding of what goes on in the schools and they may be too tired from their own largely physical labours to take the trouble to find out. Furthermore the lack of stimulation from newspapers and television all contributes to the difficulties these children from low income families have and all this helps to deepen the rift between home and school. In chapter 6 in the transcripts of the interviews, one subject insisted that Sun City was 30km's from Phokeng although the picture problem clearly showed 36km's. After some questioning the Interviewer realised that the subject "knew" Sun City was 30 km's from information gathered outside of school - there was indeed a road sign on the outskirts of Phokeng which said "Sun City 30". This subject was confused by the conflict between school knowledge as represented by the picture problem and home knowledge as represented by the real life situation. Other subjects did not have any difficulty here because apparently they were able to shut off their home knowledge and deal with the picture problem as it was given to them. This is an example of how those students whose homes promote embedded thinking are advantaged in the school situation as compared to others.

Another approach to understanding the effect of language on learning is that of Bernstein. He became interested in the process of cultural transmission during the time he spent running boys' clubs in London. This interest was further deepened when teaching at City Day College where most of the students were apprentices. He noted the clash in the value system of the students and staff and the lack of interest and short attention span of the boys in most of the school work. On the other hand he observed that these same boys could listen avidly for up to 50 minutes to lectures on motor mechanics and other subjects in which they were interested (Bernstein 1971, P. 2 - 5). These observations led Bernstein into research in the sociology of language and especially how language can operate in social control. He proposed the first step for linking meanings and their linguistic realization was to distinguish between particularistic and universalistic meanings. The former are context dependent and the latter are relatively context independent (ibid P.14). This important distinction provides a basis for understanding the poor performance of some students in the picture problems discussed in chapter 6. Some of these students were unable to move away, in their thinking, from their own lived experience and deal with the hypothetical problems presented to them in the picture problems. In his later work Bernstein further developed the idea of codes (1977, P.136). His major contribution to education is his work on elaborated and restricted codes which characterise the different socio-economic levels of society and which can help to explain the relationship between SES scores given earlier in this chapter with poor performance in the picture problems. In sections 7.2. and 7.3. above it was shown that those students who performed well in the picture problems had significantly higher SES and Degree of westernization scores than those who performed badly. It seems the latter group are closely related to Bernstein's restricted code users. They operate best at the concretely descriptive and narrative levels of communication since these are more appropriate for their lives than the analytical and the abstract.

From Bernstein's theoretical position it would then appear that improved mathematics teaching and learning can be promoted by helping students move away from the particularistic into the more universalistic use of language which is characteristic of the elaborated code. Abstraction and concept formation is seen as a major step in this move and this must receive much more attention in maths classes.

The findings of many researchers such as Macnamara (1966 and 1967) quoted earlier, indicate that it is particularly in that section of mathematics where reasoning is involved that poor language proficiency hinders most. This can be easily understood from the following example of the difficulty experienced by students in the comprehension of English recorded at Bafokeng High School in March 1988. The subjects were all doing Maths and Science in their matric year. The topic being taught was about electric charges. The subject matter was presented in the traditional way using the standard 10 physical science text book. Several demonstration experiments were carried out including the one referred to in the question below, using a hand operated van der Graaf generator. The class test on this section of the science syllabus included one of the questions taken from a matric science paper (standard grade) as follows:-

> A light conducting sphere is hanging from a long silk thread near the charged dome of a van der Graff generator. The sphere is pushed against the dome and released. What happens? Explain.

Out of 48 students who took the test 17 did not attempt this question. Of the 31 who did attempt it, only 16 showed they understood the phrase 'light conducting sphere' and 15 showed they did not understand that 'light' meant 'not heavy'. Examples of this lack of understanding were:-

> ... when the light strikes the dome the thread shines ... the light will be burned ... the light is reflected ...

From this it can be seen that only 33% of one matric class could read with adequate comprehension this particular question taken from a former exam paper. It is given here simply to illustrate the magnitude of the problem students working in a second language experience in their studies in school. For the record 13 of the 16 students who did understand the question were 'good maths students' from their matric results, 6 of the 15 who attempted the question but did not understand it properly were 'good maths students' and only 3 of the 17 who did not attempt the question were 'good maths students'. What this example shows is that inability to comprehend written English can make it difficult if not impossible for students to work a given problem simply because they do not understand what they are asked to do.

The standard of achievement in mathematics at high school level is abnormally low and has given rise to grave concern as was pointed out in chapter 2 section 2.2.. Discussing problem areas in the acquisition of mathematical concepts by black children in South Africa, Michau (1978, p.22) suggests that it is not at high school level however that the grounds for the poor achievement are established. The roots of the problem would appear to lie in the cultural background of the child and in his early school years. Michau goes on to remark that the obvious way of discovering what maths concepts exist in a culture is to examine the language of that culture for words which denote such concepts (*ibid*). Caution must be exercised especially by western investigators who will tend to use the maths framework known to them and may overlook maths concepts of a different kind which may exist in the other cultures (*ibid* p.23). In spite of this warning the present research must confine itself to the maths concepts used in the schools since we are dealing with the attainment as defined in chapter 2. It is necessary therefore to limit the investigation here to number concepts and it must be left to future research to find out what general maths concepts exist in Setswana.

Two approaches to the language question were adopted. The first one was to study the Setswana vocabulary and common usage of words to find out how numbers are named and used in the language. The second one was to observe students and teachers in a variety of school situations and to record their use of Setswana relative to English.

7.4.2.2. Maths number concepts in Setswana

The chief topic of interest in this research was 'number'. It became clear in the interviews presented in chapter 6 that the group of students who performed poorly in the picture problems had difficulties in the following areas:-

i) abstraction of number and understanding of the number line;

ii) ability to carry out simple arithmetic computations with integers;

iii) selection of the appropriate operation to solve the given problem.

It was decided that a series of non-structured interviews with people whose home language was Setswana but who could communicate fluently in English was the best way to gather data. Ten such people were interviewed, the ten included 2 ordained Church ministers, 3 high school teachers, 2 middle school principals, 1 college lecturer, 1 nurse and 1 social worker. The results were cross checked until the researcher was satisfied misunderstandings had been cleared up and broad agreement had been reached. Consistencies in the replies of the interviewees was the sole criterion of the validity and reliability in this work. In middle school mathematics the numbers studied are those belonging to the system of integers and rational numbers.

In Setswana it appears that the number system is very poorly developed and it would be impossible to do school maths through the medium of Setswana. The following facts emerged:-

1) There is a cumbersome system of naming numbers in Setswana e.g. six is 'thataro' (literally 'big three').

2) Only the positive integers have words in Setswana.

3) These words for the positive integers exist only as adjectives and are used only to qualify a noun and

nevur on their own. e.g. 'setilo sele se<u>ngwe</u>' = 'one chair', where the stem - <u>ngwe</u> = one, and 'monna a le mo<u>ngwe</u>' = 'one man' using the same ste ; twoness is indicated by the stem - <u>edi</u> as in ditilo tse di <u>pedi</u> = 2 chairs and 'banna ba bab<u>edi</u>' = 2 men.

4) The same stems are used to translate such words as 'a certain man' which is written in Setswana 'monna mongwe'.

5) There are no negative integers in Setswana and the concept seems a very difficult one for the children in school. Some attempts have been made to find a Setswana equivalent such as 'nts a lesome' for "negative 10" but all those interviewed reject this kind of made up word which they say means, literally, something like 'remove 10'.

6) There is no acceptable word for 'zero' although 'lefela' is sometimes used in school; this word is made from the adverb 'fela' meaning 'only' and given the status of a noun by the use of the prefix le-.

If one wishes to make a statement like 'there is no person in the room' a Motswana will not use 'lefela' but rather 'ga gonna motho mo kamoreng'. Sometimes 'sepe' meaning 'nothing' is used. You cannot say 'lefela apples' there is no such concept in Setswana as "zero apples".

7) Rational numbers don't exist in Setswana and such words as are used like 'ntlha nngwe' for 1/2

literally mean the 'first part of the one' or 'one side'. Others use 'seripa gare' =1/2, from 'seripa' (= part) and 'gare' (= centre).

8) Some of those interviewed suggested that the concept of 'oneness' is expressed in Setswana by 'bongwe' but it is not used for 'one' on its own. It can be used in phrases such as:-

'bongwe ba pelo' = wholeheartedly, or 'bongwe ka bongwe' = one by one.

From this discussion it can be seen that children from homes where only Setswana is spoken have developed very poor number concepts before they come to school and if they are taught in the same manner as children from English speaking homes, they will have serious difficulties in mathematics.

The above findings also help to explain the difficulties experienced by some students in the number line problem of chapter 6; some have not yet successfully abstracted the concept number and they saw no contradiction in counting 30, 31, 32, 33, 34, 40, and skipping all the integers between 34 and 40.

7.4.2.3. Preferred use of language

Because of his unique position as teacher as well as researcher in the Bafokeng region, the researcher was able to carry out numerous observations of students and teachers in the school situations as regards their preferred use of language. Two main functions of language have been identified above as communication and thinking. Of these the first was easy to observe but a number of occasions did arise when people could be asked about the latter also. The data are given in two sections: that pertaining to students firstly and then that pertaining to teachers.

(a) <u>Students' preferred use of language</u>:

Over a two week period in October 1987 a group of mixed ability standard 10 students were revising mathematics for 1 to 2 hours daily under the supervision of the reseacher.

They used a mixture of Setswana and English. The technical vocabulary was English. For example, in Geometry they used such words as congruent, similar, tangent; in Trigonometry they always used the English word for sine, cosine etc; in Algebra they used the words like y-intercept, x-axis etc in English. But verbs, prepositions, commands and such-like were always in Setswana for example:

Bona! (look) triangle ABC e na le (has) angles tsepedi (two) jaaka (the same as) triangle DEF ... ga di re (isn't it so?) ...gongwe (if) XYZ similar DEF then ABC similar XYZ.

There was no difference between good maths students and students who were not good in maths in the manner of language preference that could be detected. During a one week period in June 1988 another group of mixed ability maths students were observed for just over one hour each day as they were revising for their mid-year examination. They invariably used English for formal maths rules but used Setswana when talking to each other and working the question. As with the other group the technical vocabulary was English. One small group of three (all very good at maths) was observed for several minutes. They were revising the 'cosine rule' in Trigonometry. They spoke to each other in Setswana but they wrote out the proof of the rule in English. The informal interview went like this:

I: What language do you use in talking to each other?

S: We use Setswana ga ke re ... re e itse sentle (because we know it well)

I: Why do you write the problem in English?

S: We must do it that way for the exam.

I: What language do you use while you are thinking?

S: We think in Setswana.

I: How can you write in English if you are thinking in Setswana?

S: We are accustomed to doing that.

All three were very definite in their claim to be thinking in Setswana. Others supported this claim but qualified it to say they made use of certain English phrases like "leave the answer in surd form" but simple direct phrases were always given in Setswana like:- "Ke di Q e se di A" (it is Q, it is not A). Two students who were considered *poor* in mathematics were using a log book to find the cosine of 79 12':-

> Bona (look)! Cos ya (of) ninety degrees ke (is) zero ... mme (but) cos ya (of) seventy-nine ke mo moleng (it is on the line) o le (of) go lebagana (to look) le (of) twelve minutes.

Not all the students claimed to think in Setswana and several - some good at maths and some not good - said they used English only when thinking about maths while still others said they switched from one to the other. Here is an extract from an interview with two very good maths students, both boys. They had been doing a Trigonometry problem using a mixture of Setswana and English as other groups had done when one boy said:-

S: C is greater than ninety degrees

I: Why did you use English now like that?

S: I don't know

I: Did you have some special reason for it?

S: No ... no reason ... I can say "C ke feta ninety degrees" (C is bigger than) but I use whatever language I can understand ... I mix them

I: Which language do you use when you are thinking?

S: I use both ... I mix them in my head

The other student disagreed and said he always thinks in Setswana.

From the material gathered it was concluded that as regards communication the students prefer to use a mixture of English and Setswana - the former for technical vocabulary and numbers, the latter for common phrases. No definite conclusion could be reached as to which language the students used when thinking. No differences were observed which distinguished good maths students from poor maths students in their preferred use of language.

(b) Teachers' preferred use of language:

Teachers as a group use Setswana when talking to each other in the staff room and in all exchanges outside of the classroom, but inside the classroom they adhere strictly to the medium of English for all the so-called content subjects such as Geography, Biology etc including Mathematics. When addressing the students formally as at morning assembly they use a mixture of Setswana and English but when teachers are speaking to students informally or when students come to the Principal's office all the exchanges are in Setswana.

The language used for morning assembly in Bafokeng High School during a two week period in May 1988 followed the pattern which is typical of schools in the Bafokeng region. The Principal took the session for each of the two Mondays. He used both English and Setswana; the formal greetings in Setswana; a pep talk in English; some changes in the school timetable in English; suggestions and the importance of studying hard in Setswana. He made frequent use of some English terms while speaking in Setswana such as: Biology, week, page, numbers, academic year, dates etc..

It was clear that as a general rule he used English when making regulations and he used Setswana when appealing to the good sense of the students and asking for their cooperation. It was also noted that the students were frequently amused and laughed at some joke or other when the Principal spoke in Setswana but never when he used English.

On the other eight days of the two week observation period two teachers used English only - one of these was the senior Afrikaans teacher and the other the senior Setswana teacher. Both spoke fluently and were very confident in their delivery. For the remaining 6 days the teachers used only Setswana. Five of these six were junior teachers and may have lacked sufficient self confidence to speak in English. When questioned they said either that they were not aware of what language they had used or else that the children "could not hear English nicely" or "they understand Setswana better than English".

The hymns sung at the morning devotions were sometimes English, sometimes Setswana. There was no obvious pattern in the choice.

During the observed lessons described later in chapter 8 all the middle school maths teachers observed used English only, the children replied only in English and of course the text-books were all in English. The custom of using English only inside the classroom for formal teaching has also been observed in all the lessons which the observer has attended whether they be of maths, science or biology by the staff of Bafokeng High School or of student teachers from one of the Colleges of Education or the University.

At the in-service courses held in the Tlhabane circuit of education which have been attended by the researcher in his capacity of maths lecturer to the middle school maths teachers it was observed that only English was used during the lectures whether the lecturer was an expatriate or a Tswana person. As soon as the lectures stopped, the teachers reverted to Setswana. When questioned about the possibility of using Setswana during a maths class all the teachers present answered with an unequivocal No! Two reasons were put forward for this: one the Inspectors won't allow it and two, the syllabus says English must be used in teaching.

7.4.2.4. <u>How language affected this research</u>

There were three ways in which this research was affected by language: selection of the sample for interviews, communication with the interviewer, reliability and validity of the measuring instruments.

(a) In the original research design a 10% sample was to be interviewed in order to "talk through" the five picture problems. It was proposed these students should be taken on the basis of 10% of each class randomly chosen but to include equal numbers of boys and girls. In the first groups randomly chosen it was found that approximately 30% of the students in the standard 7 classes were not sufficiently proficient in English to enable them to carry out the interviews in a meaningful manner. Two alternatives suggested themselves:-

(i) To use an interpreter. This was rejected because of the new complexities the presence of such a third person would introduce, especially as the interpreter would be required only for some of the students.

(ii) To train a bilingual interviewer, one who could use Setswana for the interviews but who could be trained in English and who could report to the researcher in English. The requirements for such a person were not only fluency in both languages but also some experience in post-graduate research in education. Even if such a person could be found, there was no finance available to pay for a minimum of 60 hours of interviewing as well as the time required for training and reporting on the findings. Hence this alternative was also rejected.

Instead it was decided to adapt the sampling procedure by limiting the selection of students to be interviewed to those who were either average or above average at maths and who in the opinion of their teacher would be capable of taking part in a meaningful exchange with the interviewer.

(b) The interviews were conducted throughout in English but provision was made to ease the students into that language gradually. The persons shown in pictures had Tswana names, they were represented as speaking about themselves in Setswana and thus giving the essential information in Setswana and only then was English introduced by the question which was written in English underneath the picture. Occasionally a subject stumbled over a word or phrase but the interviewer's limited knowledge of Setswana enabled these difficulties to be overcome. In a few instances a subject remained completely silent but opened up readily in English after a few non-directive questions like:-

Ke mang? (who is this?) O tswa kae? (where has he come from?). There was no serious break-down in communication between the interviewer and subject apparent during any of the interviews.

(c) The third problem presented by the language factor was the one concerning the reliability of the answers to the measuring instruments administered to all the population. Efforts were made to eliminate difficult words by running a pilot study and rewording whatever seemed problematic. In spite of this a few words were still not understood, as became apparent to the markers during the scoring of the questionaires. Such instances were counted and the figures given as a consistency of response percentage in table 7.6. for the socioeconomic instrument and in table 7.12 for the degree of westernization instrument.

7.4.3. Perception

As explained above two aspects of culture were explored to arrive at a deeper understanding of the relationship between the variables reported in this chapter viz. socioeconomic status and degree of westernization - with the dependent variable viz. mathematics performance. Language was dealt with in section 7.4.2. above and now perception is dealt with here.

In the picture problems of chapter 6 it became evident that some students were unable to understand the pictures. What they perceived and what the interviwer intended were not the same. Some subjects were so confused by the drawings that for example in picture number 1 they were unable to do the question. In chapter 6, section 6.2.3. it was reported that 11 of the 60 students interviewed said they thought the drawing of the post which was part of the road sign was for them the tar road from Rustenburg to Sun City. When this part of the picture is isolated from its context it is simply an elongated rectangle. It was necessary to return to the literature to see what other researchers had found and to find out if there were some guidelines for further research which might be done in the Bafokeng region.

Another perceptual problem was the tendency towards literal interpretation shown especially by students weak at maths. In the number line problem several responded to the question "What number is shown at A?" by insisting "no number" which is the literal truth. In reponse to the apple tree question, which showed only one tree with six apples, several insisted six was the answer, even though the boy said he had eight other trees just like the first one.

It seems this "literal interpretation" is due to the inability of many poor maths students to visualise what is not actually shown in the drawing.

7.4.3.1. Literature

Perception has been an important topic in educational psychology since it was first realised that a given physical stimulus did not invariably produce the same effect within different individuals. What any one person made of the stimulus depended to a large extent on their previour experience. Different people attach different meanings to what they see or hear. The word perception can be defined in terms of a process:

> Perception is the name given to the human ability to process, interpret and attribute meaning to the information received via the sensory system (Jordaan & Jordaan 1989 P.329).

In chapter 4 reference was made to Gestalt literature and in the pilot study an attempt was made to use this approach to understand how the Tswana learn mathematics. No usable data were generated and the tests described in the pilot study were not used in the main research.

In chapter 3 the work of Witkin and others has been reviewed in section 3.2.5. In 1954 Witkin published his findings relating to perception of the upright and how this varied am individuals. He soon began to associate certain personality characteristics with the manner of perception. Field dependence and field independence came to be accepted as cognitive styles. The relationship of field dependence with child rearing practices which are specific to a given culture were investigated by Wober (1966) Dawson (1967) Okonji (1969) among others in crosscultural studies involving African subjects. It was found that African subjects were more field dependent than American or European subjects and they scored lower on embedded figures tests.

When it was found that mathematical aptitude correlated positively with speed in embedded figures tests and that field independent persons performed better in mathematics than field dependent ones it seemed as if this line of research could be fruitful in the present study. But the research done by Wober (1966 and 1978) and others in the seventies began to cast serious doubts on the tests used, by claiming they were culturally biased. Furthermore it has been pointed out that perception is just one cognitive function and care must be exercised in extrapolation of findings in this function to other functions.

> ... it can be said that there is a body of evidence suggesting that cultural differences in perception may result in some part from adjustment of the individual's perceptual mechanism as a result of frequent exposure to certain types of stimuli. Whether such an effect also influences psychological functions such as memorization or classification of stimuli which involve to a large extent a subject's deliberate participation is less clear (Deregowski 1978, p.138).

In the eighties there has begun to emerge a new line of investigation which concerns itself directly with children's learning and now there is available a considerable body of research findings on how children learn mathematics. Lesh and Landau (1983, p.xi) could speak about "a community of scholars which was beginning to emerge at the interface of several branches of psychology, mathematics, and mathematics education".
Several volumes containing reviews of research in this field have been published (e.g. Carpenter <u>et al</u> (1982) have used the interview technique to find out how children understood mathematical concepts). Ginsburg (1983) devotes a whole chapter to a discussion of protocol methods in research on mathematical thinking which were found to be very helpful in designing the present research. What has been happening is a move away from educational psychology and a greater emphasis on the individual learner. Research is now tending to

focus on how the child copes with a given situation and the aim is not simply the advancement of theory but more successful teaching and learning in the school environment. This new approach can be summarised in the words of Bishop (1983, p.197) as follows:-

> ... working in the field of mathematics education, one sees empirical research as a way of shedding light on curricula and pedagogical issues by collecting data systematically, by interpreting those data, and by reflecting on their implications in relation to practice and to other research. The search is not necessarily for consistent theory, but for alternative ways of construing phenomena and for ideas that will enable us to derive better tests, task materials, teaching materials and procedures, and educational practices to enable more children to feel successful and confident in mathematics (Bishop 1983, p.197).

It was therefore decided that for the purposes of the present research it would be best to concentrate on the practical approach in seeking a deeper understanding of what perception means for standard 7 students in the Bafokeng region grappling with mathematics learning, Therefore the work of Bishop in Papua New Guinea and that of Gay and Cole in Liberia were used as the basis for further study.

(a) Bishop investigated the problems which students in Papua New Guinea experienced with geometrical and spatial ideas in mathematics and science. A special test of fourteen items was developed containing problems which involved diagrams and other visual representations common in mathematics. There were included two-dimensional pictures of three dimensional situations and the conventions of dotted lines, perspective etc (Bishop 1983, p.187). In analysing the results Bishop claims that poor performance o many of the tasks was due, not to poor spatial skills, but rather to unfamiliarity with Western conventions. These conventions make the supposedly realistic drawings we use, to be not instantly recognizable by someone from another culture which does not use these conventions (ibid p.193). This work has shed considerable light on the difficulties of visual perception among non-technological people. He identified one ability among others, which he termed "the ability of interpreting figural information" and he suggests it depends largely on learning the conventions associated with drawings and other figural material (ibid p.184).

Deregowski defines "picture" thus:

> A picture is any surface pattern which is such that it evokes an ambiguous percept, the ambiguity resulting from the mutually exclusive notions of the pattern as it stands and of the pattern as a representation of an object (Deregowski 1980, p.97).

In picture problem number 1 the pattern as it stands is an elongated rectangle but what it represents is an upright post. All but one of the 11 subjects who had difficulty in interpreting the figural information were poor performers in their overall scores for the picture problems i.e. they scored an average of less than four out of ten for the five problems.

(b) In Liberia Gay and Cole (1967) noted the link between the naming of a concept and the existence of that concept in the Kpelle culture and not unexpectedly they name only those geometric shapes in common use in their culture (Gay and Cole 1967, p.61). Children are very much influenced by their home culture and there is an enormous problem in teaching a concept which is new to the culture. One reason for the difficulty must undoubtedly be traced to perception. If a particular visual stimulus, for example, a triangle, has no meaning in a culture then it will not easily be the subject of a perception for a person limited to that culture. Gay and Cole (1976, p.57) state:

> Perception in the culture is linked to the level of complexity of the terms available in the language.

It will be shown in the next section that the Tswana have a highly developed level of perception of the concept "circle" but a very poorly developed one of "rectangle".

The authors quoted remark that concept identification experiments show that shapes named by nouns are more easily recognised than shapes not named, and that learning involving these shapes is usually very difficult (Gay & Cole 1967, P.61). From these considerations they went on to investigate verbalization and learning by designing experiments which they call "verbal mediation" experiments. The apparatus used consisted of blocks which had two variable properties - length and colour so that the blocks could be either long or short or either green or white. In the first series subjects were trained in perceptual identification of colour and in the second series the identification was shifted to length. The question being studied was by what process had the Kpelle subjects arrived at the solution to the problem. The authors propose that it was either (i) by learning two seperate responses involving the absolute properties of the correct block in each pair or (ii) by learning a verbal label for the correct type of stimulus. The verbal label mediates the move from one stimulus to the other (P.85/86). The authors refer to the work of the Kendlers (1964) who found that among American children at kindergarten age fast learners showed the mediated pattern of verbal thinking whereas slow learners relied on nonverbal thinking. The use of verbal labels in the thinking process is a characteristic of older children and adults. What the Kpelle verbalises and how he verbalises it depends very much on the degree to which the topic or problem fits into his cultural framework (<u>ibid</u>. P.88).

In order to explore in greater depth how perception affects learning among the Tswana three experiments were designed for this research. They were:-

1) Response to a simple visual stimulus;

2) Knowledge of Setswana words to describe geometric

shapes;

3) Organisation of data in a problem situation.

Details of these experiments and the findings are given in the next section.

7.4.3.2. Perception Experiments

1) Response to a simple visual stimulus

It was hypothesised that students'perception of a simple drawing would be largely influenced by the mind set operative at a given time during the school day. It was further thought that students would associate the stimulus with a given school subject identified with a particular teacher. The stimulus used was a large circle drawn on the blackboard in white chalk by the teacher at the start of a lesson. The subjects were 195 standard 8 students. The instruction given was to write on a piece of paper what they saw. The results are summarised in the following table:

Table 7.23 Students' reponses to circle stimulus

			WHAT THE STUDENTS SAW				
CLASS	SUBJECT	N	LANGUAGE	CIRCLE	EARTH	CELL	OTHER
8A	Maths	39	English	38	0	0	1
8B	Geography	53	English	42	10	0	1
8C	Biology	56	English	38	1	16	1
8D	Setswana	47	Setswana	43	2	1	1

The replies listed as "other" in the above table were ball, balloon, egg. The results confirmed the hypothesis - a fairly large number of students thought the circle was representing the earth at the start of the Geography class and a somewhat larger number thought it represented a cell at the start of the Biology class whereas all the students except one thought it was a circle at the start of the mathematics class. These numbers are not as large as one might have anticipated and it shows that a teacher cannot take it for granted that his or her very presence in his capacity as the teacher of a particular subject will be sufficient to bring the mind set required for the subject into operation. However it was the replies of the 8D class that yielded the most interesting results. Five differnt words were used each of which could be roughly translated as "circle" but on questioning it was discovered that each word had a more precise meaning.

Each word expressed circularity or roundness in a special context as follows:-

a) round in the sense of a figure on a flat surface e.g. the drawing of a circle in the sand on the ground;

b) round in the sense of a flat disc which can be picked up e.g. a plate;

c) round in the sense of a ball having three dimensional properties e.g. stone, lump of dough, fruit;

d) round in the sense of enclosing space e.g. cattle kraal and even a boxing ring;

e) round in the sense used in mathematics like a cirlce drawn on the board. This seems to differ from a) above but not clearly understood by the researcher and not well explained by those interviewed.

The conclusion which must be drawn from these results is that the concept of circularity is very well developed among the Tswana.

2) <u>Setswana names for geometric shapes</u>

Research into cultural influences on perception was carried out many years ago in South Africa by Allport & Pettigrew (1957) who studied how the Zulu language influenced perception of illusions among the Zulu people. Because the Zulu language has no words for the concepts square and rectangle it was deduced that these concepts are unknown in Zulu culture. Hence the Zulu people cannot easily form a conception of squareness and rectangularity and are thus unable to apply such concepts to their perceptions (Jordaan & Jordaan 1989, P.367).

The question posed here was about possible words in Setswana for various geometric shapes which are common in mathematics. Ten shapes were drawn on a page and subjects were asked to write the name in Setswana and in English beside each shape as shown in appendix H. These were distributed to two groups (i) twenty-four male stu-

d) round in the sense of enclosing space e.g. cattle kraal and even a boxing ring;

e) ro[illegible] in the sense used in mathematics like a cirlce drawn on the board. This seems to differ from a) above but not clearly understood by the researcher and not well explained by those interviewed.

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Table 7.24. <u>Scores for names of geometric shapes by adult males</u>

	FREQUENCY	
SCORE	SETSWANA	ENGLISH
10	2	5
9	0	1
8	0	3
7	1	3
6	2	3
5	2	2
4	5	1
3	8	1
2	4	3
1	0	0
0	0	2
TOTAL RESPONSES	24	24
AVERAGE SCORE	4,2	6,0

From this table it can be seen that the subjects have more labels for geometric shapes in English than in Setswana.

However when the Setswana words were examined it was discovered that there were no specific words for the shapes and the words were all derived from the single word "khutlo" meaning "a corner". Thus "Rectangle" = four corners. It must be concluded that the concept of rectangularity is very poorly developed in Setswana.

The same test was administered to a sample of 60 middle school students drawn from 473 students. The sample was composed as follows:-

One standard 5 class was drawn at random from four classes and then the students were divided by the maths teacher into students good at maths and students poor at maths. Ten students were drawn at random from each group to make 20 standard 5 students, 20 standard 6 and 20 standard 7 students.

The purpose of this test was two fold: first to see if there were significant differences between good and not good maths students at the middle school level and secondly to see if there was any marked progression in ability to name geometric shapes in the successive standards.

The test was that shown in appendix H and consisted of 10 common geometric shapes which the subjects were asked to name in both Setswana and English. Marks were awarded by giving one point for each correct word. The maximum score was 10 for Setswana words and 10 for English words. The average scores are given in Table

7.25.

Table 7.25. Average scores for names of geometric shapes by middle school students

CLASS	N	SETSWANA		ENGLISH	
		GOOD	POOR	GOOD	POOR
Std. 5	20	16	30	57	46
Std. 6	20	42	48	51	50
Std. 7	20	32	15	83	49

From these results it can be seen that in all standards for all groups the average scores in English are higher than the corresponding scores in Setswana.

In std. 5 and std. 6 the students in the group of students whom their teachers consider to be poor at maths scored higher averages in Setswana names than the group who were considered by their teacher to be good at maths.

This was reversed in std. 7. There was no significant difference using χ^2 test between the two groups for average scores in English names for std. 5 and std. 6 but there was a big jump in the average scores in English names in the std. 7 class with the good maths students average 8,3 compared to those poor in maths who only averaged 4,9 ($p < 0,01$). There was no clear progression from class to class in the ability to name shapes.

Eight teachers were interviewed to help in the analysis of the results and one of these said:-

> These figures are not traditional among the Tswana people. The old people wouldn't know any words for them. In schools we have just coined words for square and triangle but generally we use the English words (Appendix A No.1).

In the light of the literature reviewed in 7.4.3.1. it must be extremely difficult for most Tswanas to learn these concepts because of the lack of these concepts in their own culture. This is not to say that it is impossible for that would be to support the so called Sapir-Whorf hypothesis which states that the language that people learn and use determines how they will perceive reality (Jordaan & Jordaan 1989 P.401). In the strict application of this it was thought that if the mother tongue didn't have a certain concept then a person couldn't learn that concept. In the experience of the researcher with the Bafokeng this is not true. People can learn to see what others see. Jordaan & Jordaan rephrase the Sapir-Whorf hypothesis thus:

> The people of a particular culture formulate intersubjectively, perceptual rules which enable them to make sense of reality and that these rules necessarily find expression in the language of the culture concerned (<u>ibid</u>).

The fact which has been established in this section is that the Tswana do not have well developed concepts for rectangularity in their language. This makes it particularly difficult for them to learn these concepts in school.

3) <u>Organisation of data</u>

The purpose of this investigation was to find out how Tswana students organise data in a problem situation and to observe if there was a difference between "good" maths students and students "weak" at maths in their approach to solving problems. Thirty-six small cardboard counters - measuring approximately 2 cms across were prepared, three different colours and three different shapes were used. The composition of the counters for each test were as shown in table 7.26.

Other arrangements of assorted numbers of each colour and assorted numbers of each shape were planned but the implementation proved too ambitious for this research and was abandoned. A separate sheet for recording observations for each subject was prepared and is given in appendix I.

The subjects were tested one at a time by the researcher. The instructions were:-

> Here are some objects. Please arrange them in four groups. I wish to give them to my four friends.

The subject was asked if the instructions were understood, and they were repeated if necessary. It was hypothesised that differences would emerge between the students who were good at maths and those who were not good at maths in the manner they dealt with the problem:

a) counting in one's, two's or some other way

b) sorting by colour, by shape or some other way

c) planning a strategy such as using arithmetic operations, trial and error or some other way

d) recognising the goal state

e) checking the result by counting or some other way

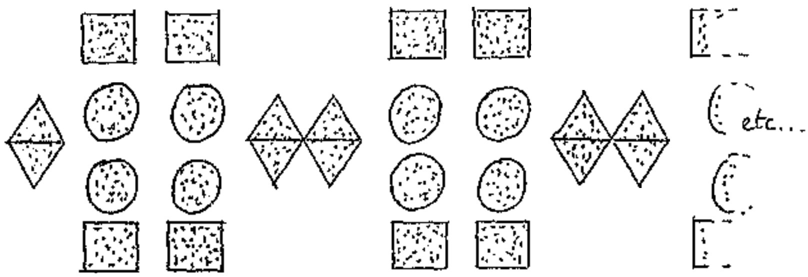
Table 7.26. <u>Arrangement of counters in the organisation of data test.</u>

TEST NAME	COLOUR	SHAPE	TOTAL NUMBER OF COUNTERS
A	all blue	all square	36
B	blue 12 red 12 white 12	all square	36
C	all blue	square 12 triangle 12 circle 12	36
D	blue 12 red 12 white 12	square 12 triangle 12 circle 12	36

It was intended to administer this test to samples drawn randomly from the middle schools. A small pre-test was carried out on four standard 8 maths students drawn randomly from a class of 39 maths students. The results of this pre-test were surprising. Only one subject was able to do the task successfully without assistance.

Two others managed after considerable guidance from the researcher and the fourth became so fascinated by the shapes as shown in figure 7.4. that he was unable to complete the task. All four took not less than fifteen minutes to finish.

Figure 7.4. Pattern made by one subject in the pre-test



It was decided to abandon the testing of the middle school students because of the time factor and instead to concentrate on standard 8 and standard 10 high school students. For this purpose 32 students were tested. These were drawn randomly from four groups arranged by their maths teacher: boys good at maths, girls good at maths, boys poor at maths, girls poor at maths - four students being drawn from each group to make up 16 standard 8 and 16 standard 10 students. The subjects were tested by the researcher singly and the results are given in Table 7.27. and Table 7.28.

Table 7.27. Performance of std. 10 maths students in "organisation of data" test

	GOOD MATHS STUDENTS			STUDENTS POOR IN MATHS		
	BOYS	GIRLS	TOTAL	BOYS	GIRLS	TOTAL
Successful*	4	4	8	1	2	3
not sure	0	0	0	2	0	2
not able	0	0	0	1	2	3
TOTAL	4	4	8	4	4	8

In the case of the sixteen std. 10 students the task proved a very simple one for the group of good maths students although only one counted and divided by four. The others distributed the counters one by one or in two's into each of four groups and checked at the end to ensure each group was the same. Of the eight students who were judged by their maths teacher to be weak in maths only three were successful; two more were able to complete the task after guidance from the researcher and three were unable. These latter sorted the counters either by colour or by shape into three groups and said they could not distribute them to four people because

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*Criterion for success in this task was the ability to form four groups each with 9 counters.

they only had three kinds of objects. These students also took a much longer time to do the task and they spent considerable time at the beginning moving the counters around before dividing them into groups. It seemed they were unable to comprehend the problem; they didn't seem sure of the goal state; and they had difficulty in devising a plan. None of them checked to see if the groups were equal.

The same general result was obtained when the test was administered to the sixteen std. 8 students but the overall performance was poorer. The results are given in table 7.28.

Table 7.28. Performance of std.8 maths students in "organisation of data" test

	GOOD MATHS STUDENTS			STUDENTS POOR IN MATHS		
	BOYS	GIRLS	TOTAL	BOYS	GIRLS	TOTAL
Successful	3	1	4	0	1	1
not sure	0	0	0	0	0	0
not able	1	3	4	4	3	7
TOTAL	4	4	8	4	4	8

Only three of the boys and one of the girls from those good at maths were able to deal with the problem successfully. They all used a trial and error method distributing the counters one by one or two by two into each of four bundles until finished. The three girls and one boy unable to do the task seemed to have the common misinterpretation of what was required. Three of them made nine bundles of four counters instead of four bundles of nine counters. The fourth had no idea of what to do. All the subjects in the group of students poor at maths except one girl - and then only after coaching - failed to make four bundles. The usual procedure of those who attempted any solution was to make three bundles either by colour or by shape and leave it at that. This group of students poor at maths differed from those good at maths not only in their relative ability to complete the task but in the time taken, their understanding of the instructions, their ability to express themselves in English and their apparent difficulty in reflecting on their own thought processes. Finally they seemed to have considerable difficulty in remembering what the problem was about and they easily got sidetracked, by the colours or shapes or patterns.

In the light of these results it seemed more important to pursue the difficulties experienced by those poor in maths and to try to find out why such an apparently simple task proved so problematic. Several informal discussions were held with teachers and matric maths students in Bafokeng High School and the following points were raised:-

i) perhaps the students didn't understand the instructions in English

ii) perhaps the students were not interested in the task which involved squares, triangles and circles - things which had no meaning for them out-side school.

The next stage in the experiment was therfore to test these hypotheses. Firstly the instructions were translated into Setswana and the test then administered to a group of std. 8 students poor in mathematics - all had failed the std. 7 examination in mathematics and they were not doing mathematics as a subject in std. 8. They were drawn at random from a class of 57. The results are given in Table 7.29. Only one was successful, two were unsure and five were unable to do the task.

Table 7.29. Performance of std.8 non-maths students using Setswana

	BOYS	GIRLS	TOTAL
Successful	0	1	1
Unsure	1	1	2
Not able	3	2	5
TOTAL	4	4	8

The results did not indicate that this line of enquiry might prove fruitful. The first hypothesis was rejected, and no further research along this line was undertaken.

The second hypothesis concerned the nature of the objects used in the test and it was decided to replace the three diffeient shapes with three different objects well known to the students and presumably of interest to them - sweets, grapes and stones were used. The results of this test are given in Table 7.30.

Table 7.30. Performance of std. 8 non-maths students using sweets etc.

	BOYS	GIRLS	TOTAL
Successful	1	3	4
Unsure	1	0	1
Not able	2	1	3
TOTAL	4	4	8

The results show a considerable improvement and half of the subjects were now able to make four bundles. No one counted and divided. One distributed in two's to each of four bundles, two others distributed one by one and the fourth just made a rough bundle into each of four corners, then checked by counting and rearranged several times in an apparantly haphazard manner until they got four equal bundles. The subject counted as 'unsure' in table 7.30. made four unequal bundles and even when questioned did nothing to check or alter the bundles. The remaining three were unable to do the task - one made six groups and another subject just said he would divide them among his friends but would not show the researcher how he would do that.

The conclusion drawn from the above tests was that the nature of the objects used does make a difference to the performance of the students weak at maths. It appears that the improved performance can be attributed to greater motivation caused by increased interest. What is not clear however is whether this interest arises from working at different levels of abstraction - the sweets, stones and grapes being concrete objects when compared to the squares, circles and triangles which represent for these students a higher level of abstraction. Pursuing this line of reasoning it was realised there was still another abstraction in the test namely the four friends who were to receive the four bundles of objects. In real life it has been observed by the researcher that when a Bafokeng child receives anything which he can share, such as fruit or sweets, he does so immediately. Now it was decided to see what effect the presence of four real people who could be described as 'my four friends' would make to the results. Four matric boys were recruited and instructed on how to behave - they were told not to say or do anything which might influence the behaviour of the subjects - they were simply to receive whatever they were given and to return it if that was required. Another eight students were picked at random from another class of 48 non-maths students ie. students who failed maths in the standard 7 examination. They were given grapes, sweets and stones - 12 of each and instructed as before to make four bundles so that the four friends (now the researcher pointed to the four boys) could each get a bundle.

The results are given in Table 7.31.

Table 7.31. <u>Performance of std 8 non-maths students using sweets etc with friends present</u>

	BOYS	GIRLS	TOTAL
Successful	2	4	6
Unsure	2	0	2
Not able	0	0	0
TOTAL	4	4	8

The results show an extraordinary improvement. All the girls looked carefully at the objects (seemed to be classifying them mentally) then looked at the four friends and distributed the sweets etc. directly to the friends - two of the subjects must have done a mental division because they gave three of each of the sweets,grapes and stones to the four friends while the oth r two distributed the objects one by one. Two of the boys also distributed the objec s one at a time and were successful. The remaining two boys ignored the friends and played around with the objects for some time before dividing them into four unequal bundles and then gave a bundle to each friend.

It was concluded from above that a major difficulty in the earlier forms of this experiment had been the inability of the students who were weak at maths to visualise four friends present to whom they could distribute the four bundles of objects which they were asked to make. Once these four were physically present there was no problem in performing the task because now they could act in a concrete situation. The final act in this drama was to repeat the experiment returning to the counters of different shapes and different colours and this time to have four friends present to receive the four bundles of objects. For this purpose 16 std. 8 students were drawn at random from non-maths classes of 58 and 46. The results are given in the Table 7.32.

Table 7.32. Performance of std. 8 non-maths students using counters with friends present

	BOYS	GIRLS	TOTAL
Successful	5	3	8
Unsure	2	2	4
Not able	1	0	1
TOTAL	8	5	13*

This test was interrupte three times. On one occassion the "friends" broke their rule of silence by telling the subject what the researcher wanted. On two other occassions the researcher was called away in the middle of the test. The three subjects involved in these three tests were not counted in the results. Two boys and one girl ignored the four friends and made four bundles of unequal numbers and they were unable to explain what they were doing. They were counted as "unsure". The other girl listed as "unsure" ignored the colour and

*The total recorded was 13 although 16 had been tested. The reason for this was an interruption of the task when the researcher was called away and three of the girls results proved unreliable due to coaching from the "four friends".

distributed the counters haphazardly to the four friends and didn't check or seem to realise she had made bundles of 10, 8, 6 and 12. She was also listed as "unsure". One boy seemed unable to comprehend and said he didn't know what he was supposed to do The remaining 8 listed as "successful" distributed the counters to the four friends one by one and checked that the bundles were equal by counting. The results show that the performance of students weak at maths is dramatically improved when four people are present to receive the four bundles of counters.

The series of tests conducted in the investigation into how students organise data in a problem situation led the research into unforeseen areas. It is now clear that what was done was largely exploartory and needs verification using more rigorous scientific techniques and involving larger numbers. None of this was possible in the present research due to lack of facilities of time and financial resources. What appears to be emerging is that the students who are weak at maths are unable to solve even a relatively simple problem at a relatively low level of abstraction. The problem required the subject to count the number of counters and to divide by four to obtain four bundles of counters. In the more difficult forms of the test the subject was required to first classify the counters either by shape or colour and then divide each class into four bundles.

This proved an extremely difficult ask for the students weak at maths. When counters were replaced by sweets, stones and grapes there was a big improvement but it was only when four people were present to whom the objects could be physically given that most of the students weak at maths could do the task successfully. It was concluded that those who failed at the task in the physical absence of four people were unable to visualise four people present to whom they could imagine themselves giving the objects.

In concluding this section we must return to the link between socioeconomic status and degree of westernization on the one hand, and perception on the other hand. An important step in perception is visualisation. The ability to hypothesise and to link abstractly requires a previous first step of being able to form a mental image.

In the tests described above there was a remarkable improvement in the performance of the students weak at maths when words "my four friends" were accompanied by the physical presence of four people because now the subject was no longer relying on a visual image of four people but could deal with four real people. When these four were not present a great difficulty was shown in focussing on the task. Both socioeconomic status and degree of westernization have a great effect on visual stimulation. In better off homes which are more westernized, there is a lot of visual stimulation compared to poorer and more traditional homes. The visual stimulation provides the mental images from which abstraction can begin. One final word must be added here about the total lack of pictorial material in any of the classrooms visited by the researcher as will be described in the next chapter. Of the twelve classrooms visited the walls were completely bare apart from a small class timetable in each of seven rooms and one calender in another room and a small (A4 size page) pencil drawing of a snail in another.

7.5. Conclusion and summary

7.5.1. Conclusion

From the material presented in this chapter on socio-economic status and degree of westernization certain pictures became clear which enabled us to distinguish between those students who performed well in the picture problems compared to those who performed badly. In the next two sections the profile of a "good" and the profile of a "poor" maths student will be drawn using the data from the S.E.S. and the Culture responses of those students.

7.5.2. S.E.S. Profile

(a) S.E.S. Profile of "good" maths student:

Both parents are alive and living at home. Both parents attended school up to standard 6 at least (6 of the 15 fathers and 4 of the mothers did std. 10). It is likely that the father or the mother is in a well paid job such as nurse, teacher, supervisor, or skilled work and none are labourers. The home is a brick house with 7 rooms and there is a 50% chance that it has running water, an indoor flush toilet and electricity. There is a fair chance that there is television in the house and that a newspaper in bought every day (four of the fifteen have T.V. and get a newspaper daily). There is a radio in the home and there is more than a 50% chance that the family has a post office box.

A constant reliable source of good light makes it very easy for a student to do homework. A student with electricity in the home is greatly advantaged compared with one who has no electricity and must rely on candles for light.

(b) S.E.S. Profile of "poor" maths student:

There is a 20% chance that at least one parent is dead or not living at home. It is unlikely that either parent reached standard 10 (2 of the 19 fathers and none of the mothers did std. 10) and it is quite likely that one or other parent did not attend school at all (14 of the 36 parents did not go to school). It is likely that the father is a labourer or unemployed or in a low paid semi-skilled job (4, 2, 9 of the 19 respectively). It is likely that the mother works as a domestic (8 of the

19 mothers are "kitchen girls"). The home is a brick house with 5 rooms and no indoor running water or indoor toilet. There is a pit latrine in a small hut in one corner of the yard described in Setswana as "ntloyana" which means literally "small house".
There is no electricity in the house and usually cooking is done outdoors using wood or coal and indoors cooking is done on a primus stove. For light they depend on candles (14 of the 19 homes) and water must be fetched from the village pump (10 of the 19). There is a fair chance (7 of the 19 cases) that there is never a newspaper in the house and the only chance of watching T.V. is when visiting a more prosperous neighbor's home. There is a radio in every home and it is listened to every day and almost half of the families have a P.O. Box. Carrying water from the village pump and chopping wood takes a lot of time and these chores are usually done by the school-going members of a family. All this uses up time and energy which might otherwise have been used for school work. Coupled to the fact that the source of light is only candles we see difficult circumstances which the students in this group face if they wish to improve themselves by doing extra study at home.

7.5.3. <u>Degree of westernization profile</u>

(a) Degree of westernization of "good" maths student:
Those students who scored A or B in the five picture

problems are more westernized than the ones who scored D or E. Most of them do have Tswana names but approximately 30% don't have a Tswana name. This is regarded as a very significant move away from the traditions of giving the child a name which links him or her to the spirit world. The traditional worship of the ancestors is less often practised in their homes and none of the 'good' maths group admit having visited a witchdoctor for traditional medicine. Regarding role identification these students think professions such as doctor, teacher, nurse, mine worker are suitable jobs for men, and nurse, social worker, clerk are suitable for women. What is significant here is that these jobs involve working outside the home and earning a salary. This is regarded as a western and not a Tswana custom although more and more of the Bafokeng do engage in this kind of paid work. Indeed the idea of working for money was introduced as far back as the last century when the Chief of the Bafokeng organised squads of young men to travel to Kimberley diamond mines to earn money which was later used to purchase title deeds for the Bafokeng tribal lands as was reported in chapter 1.

This group of "good" maths students strongly reject as being old-fashioned certain traditional customs such as:

(i) shaving the head after the death of a relative

(ii) making bojalwa (traditional Tswana beer) for funerals

(iii) using fingers to eat from a common bowl

(iv) paying lebola (bride price) for a future wife

(v) children being reared by grandparents

(vi) reporting disputes to the Kgotla (tribal court)

(vii) going to circumcision school

(viii) carrying loads on the head

But the group as a whole still considers certain customs to be good such as:

(i) go pepa ngwana (carrying a baby on its mothers back)

(ii) waiting until properly married before having a baby

(iii) doing mmino wa setso (tribal dancing)

(b) Degree of westernization of "poor" maths students:

In general the students in this group are not westernized in the sense that the group of "good" maths students are. The "poor" maths students come from a more traditional Tswana family. All have a Tswana name, given by the grandparents, which in Tswana culture links the child with the badimo (ancestors). There is a strong belief among these students in the traditional healing; according to this view trouble is caused by angry spirits, often stirred up by an enemy, and the cure can only be obtained from a witchdoctor. Six of the 19 "poor" maths students say they have visited the witchdoctor.

Most of this group have very clear opinions on what type of work is suitable for men and what is suitable for women. They say men should look after the cattle, build houses and do farm work and that women should stay at home, take care of the house and look after the children.

As a group, and in this they are not different from those "good" at maths, these students reject circumcision schools, washing clothes at the river, carrying loads on the head and eating from a common bowl using fingers. But in contrast to the "good" maths students these ones regard the following customs as being right and proper for everyone today:

(i) making traditional Tswana beer for funerals

(ii) wife remaining indoors for months after her husband's death

(iii) paying bride price for a future wife

(iv) reporting disputes to the Kgotla

7.5.4. Summary

The main findings of this chapter are that both of the home variables studied are significantly related to mathematics as defined by the performance in the picture problems. The figures for each are:

r (S.E.S. and picture problems) = 0,433($p < 0,01$)

r (degree of westernization and picture problems) = 04,979($p < 0,01$)

Similarly it was shown that the variables are not significantly related to the maths marks and the figures were given in the relevant sections. Since this latter finding is so different from the bulk of other research into SES and achievement it casts serious doubts on the validity of the maths exam mark as a criterion for success.

Also in this chapter the relationships between SES and culture on the one hand and performance in the picture problems on the other hand was explored by investigating the Tswana language and perceptual modes especially among the group of students who performed poorly in the picture problems. What emerged from this deeper investigation was seen to relate to low levels of abstraction among these students.

CHAPTER 8

SCHOOL VARIABLES

8.1. Introduction

In the research design of chapter 5, three sets of variables were put forward as providing possible answers to the research question. The present chapter is devoted to the school variables which were investigated in order to find relationships between these variables and the two criteria of success given in chapter 2. The scores for each school in the maths examination and in the picture problems are given in section 8.2. and the difference between students good at maths and students weak at maths are analysed. In order to find out what previous research had uncovered about the effect of schools on mathematics achievement a search of relevant literature was undertaken and this is reported in section 8.3. The purpose of this search was twofold: to find out what previous research had uncovered relative to the effect of schools on mathematics achievement and to find a possible theoretical framework for the study of the Bafokeng schools. What emerged from the literature was that several models for classroom observation do exist but none that could be used or adapted for the present research given the delimitations of the present study. Neither was there found a suitable instrument for classroom observation of the middle schools of Phokeng. Hence in the present chapter the data is descriptive only and no attempt was made towards quantification. In section 8.4. the school environment, location, history and relations between the teachers are given. Then what actually occurs in the classrooms during mathematics lessons is described. It was hypothetised that inservice training of teachers in mathematics would have a great effect on what the teachers actually did inside the classroom during mathematics lessons. Therefore section 8.5. consists of a report on inservice training in the Thlabane circuit. The researcher visited each maths teacher in the study and spent one full mathematics period with each teacher in his/her classroom and what was observed is given in section 8.6. Since no suitable model for classroom observation had been found in the literature it was decided to use the model developed in chapter 5 section 5.3. in order to structure this data. The focus was on the students learning mathematics, not on the teacher teaching mathematics. The model as shown in Fig. 5.4. has four parts:

1. a present state which must be perceived by the student and involves disembedding relevant information from what is given;
2. a goal state also derived by the student from the given information;
3. a plan by which the student proposes to move from

1. to 2.

4. a checking system which enables the student to check that the goal has been reached and that no errors have been made.

During the class visits, both inservice and std 7 maths lessons, the researcher concentrated on the above procedure and paid particular attention to identify occasions when the teaching helped to develop this kind of approach to problem solving. There was no attempt to establish reliability for these observations and the lessons were taken as typical lessons and not special ones in order to put on a show for the researcher. In point of fact there was nothing "special" about any of the lessons with one notable exception as described below in section 8.6.

The chapter closes with some extracts from a diary kept by a student teacher during two weeks of teaching practice. In this diary the student teacher describes how he attempted to change the attitudes of a middle school maths group towards the subject and how the students responded. The students developed a new interest in maths. This item is important in the light of the findings of chapter 9 where attitudes to maths is shown to have a very strong positive correlation with success in maths.

8.2. Differences between the schools

8.2.1. How the schools were compared

Two criteria for success in mathematics were used in this research viz. performance in the std 7 maths exam and performance in the picture problems.

When the performance of the students at each of the three middle schools was examined using these two criteria of success certain differences emerged. In this section the schools are compared, first with the reference to the standard 7 examination in 8.2.2. and then with reference to the picture problems in 8.2.3. The differences which became evident are discussed in 8.2.4.

8.2.2. Performance in the std 7 maths examination

The standard 7 examination was introduced as an external examination in 1984. Matale and Mafenya had been functioning as junior secondary schools for several years before that and these schools entered candidates for the std 7 examination in that year. Keledi on the other hand had been upgraded from primary school status and had no standard 7 students until 1985. The results for each school are given in Table 8.1. together with the national average for Bophuthatswana for comparison. The numbers given in this table are the actual numbers who passed before marks had been adjusted. The figures were taken from the computer print out of results supplied to the schools by the standard 7 examination board. For the purposes of the standard 7 examination, pass is considered 33% or above.

Table 8.1. Standard 7 maths results (external examination)

YEAR		KELEDI	MATALE	MAFENYA	NATIONAL (BOPHUTHATSWANA)
1984	Number entered	0	334	95	26 675
	Number passed	-	60	23	7 279
	Percentage		18%	24%	27%
1985	Number entered	184	257	124	32 083
	Number passed	26	36	27	9 375
	Percentage	14%	14%	22%	29%
1986	Number entered	317	231	108	31 935
	Number passed	12	15	17	5 616
	Percentage	4%	6%	16%	18%
1987	Number entered	317	182	126	34 166
	Number passed	126	51	35	14 666
	Percentage	39%	28%	28%	43%
1988	Number entered	216	190	133	34 881
	Number passed	47	31	25	9 108
	Percentage	22%	16%	19%	26%

Several points are of interest from these figures. Firstly all of the three schools had pass rates below the national average for the five years. Secondly the pass rate figures ar 'ary uneven. Thirdly the pass rate for Mafenya students is higher each year than that of Matale. Fourthly all three schools showed a big improvement in 1987 (this was the year when the present research was being carried out and the researcher made several visits to each of the schools). Fifthly Keledi scored higher than either of the other two schools in 1987 and 1988. For the statistical analysis the 1987 June (internal) examination marks were used and the figures for this examination are given in Table 8.2.

Table 8.2. Standard 7 maths results (internal examination)

YEAR		KELEDI	MATALE	MAFENYA
1987	Number entered	323	183	129
	Number passed	165	56	42
	Percentage	51%	31%	33%

It can be seen from this table that very few students dropped out of school between June and November of 1987. The figures also show the same pattern as the corresponding figures for the external examination viz Keledi had a higher pass rate than either of the other two schools. Lastly students from all three schools performed better in the June examination than in the

November (external) examination. It is impossible to judge what effect, if any, the visits of the researcher might have had on the students' performance because even though each school showed an improved pass rate in the November (external) examination for 1987 there was also a big improvement in the national average for that year.

8.2.3. Performance in the picture problems

Sixty standard 7 students were interviewed as reported in chapter 6. The sampling procedure was given in chapter 5. The performance of these sixty students according to schools is given in Table 8.3.

Table 8.3. Performance in the picture problems

	KELEDI	MATALE	MAFENYA
Number interviewed	32	16	12
Number scoring A or B (good)	5(16%)	6(38%)	4(33%)
Number scoring C (average)	12(38%)	10(63%)	4(33%)
Number scoring D or E (poor)	15(47%)	0 -	4(33%)

From this table it can be seen that the performance in the picture problems is the opposite to the performance in the maths examination i.e. Keledi students scored much lower marks than students from the other two schools and Matale students scored higher than the others. A full 79% of the category "poor performance in the picture problems" are Keledi students, none are from Matale. On the other hand 40% of the category "good performance in the picture problems" are Matale students and only 27% are from Mafenya.

8.2.4. Comparison of the schools on independent variables

In chapter 7 and chapter 9 certain variables were measured using instruments designed for that purpose and described in those chapters. The scores obtained by each school on some of these variables are given in Table 8.4.

Table 8.4. Scores obtained in the independent variables

VARIABLE	SCHOOL								
	KELEDI			MATALE			MAFENYA		
	N	MEAN SCORE	s.d.	N	MEAN SCORE	s.d.	N	MEAN SCORE	s.d.
Age	300	16,7	3,2	154	16,2	2,3	125	16,5	2,0
SES	301	19,6	6,2	157	24,5	6,1	126	20,0	4,6
Culture	301	9,7	18,1	157	6,9	19,6	126	9,3	21,1
Attitude	301	10,1	6,6	157	11,7	6,1	126	9,4	8,7
Self Con	301	5,8	2,9	157	7,1	2,9	126	6,0	2,5
English	297	42,6	10,5	157	41,9	9,1	126	30,9	7,3

It can be seen from Table 8.4. that Matale students are different from the other two groups; the Matale students are on average younger, have a higher socio-economic level, have more positive scores on attitudes and self-concept than the other two. Furthermore their culture scores indicate these students are more westernized than the others.

Correlations between the independent variables in Table 8.4. and the June 1987 maths marks were calculated using the Spearman formula and the levels of significance are given in Table 8.5.

Table 8.5. Correlations between the variables and maths mark

VARIABLE	SCHOOL		
	KELEDI	MATALE	MAFENYA
Age	n.s.	$p < 0,05$	$p < 0,05$
SES	n.s.	n.s.	n.s.
Culture	n.s.	n.s.	n.s.
Attitudes	$p < 0,01$	$p < 0,01$	$p < 0,01$
Self-concept	n.s.	$p < 0,05$	n.s.
English	$p < 0,01$	$p < 0,01$	n.s.

It can be seen from this table that attitudes correlates positively with maths mark for all three schools.

English marks also show a strong positive corr lation for Keledi and Matale but strangely not for enya. Self-concept is significant only for Matale.
Correlations were also calculated between these same variables and the picture problem scores and the levels of significance are given in Table 8.6.

Table 8.6. Correlations between the variables and picture problem scores

VARIABLE	SCHOOL		
	KELEDI (N = 32)	MATALE (N = 16)	MAFENYA (N = 12)
Age	$p < 0,05$	n.s.	n.s.
SES	$p < 0,01$	$p < 0,05$	n.s.
Culture	$p < 0,01$	$p < 0,05$	$p < 0,05$
Attitudes	$p < 0,01$	$p < 0,05$	n.s.
Self concept	n.s.	n.s.	n.s.
English	$p < 0,01$	$p < 0,05$	$p < 0,01$

The three schools show a positive correlation between English mark and picture problem score and also between culture (a gree of westernization) ard picture problem score. There is no correlation between self-concept score and picture problem score for any of the schools. What differentiates the students from each s ool are:
1. Age: Keledi students have a small ir .se relation

between age and picture problem score unlike Matale and Mafenya students.

2. SES: Mafenya students have no correlation between SES and picture problem score unlike Matale and Keledi.

3. Attitudes: Again Mafenya students have no correlation between attitude score and picture problem score unlike Matale and Keledi.

It has been shown in section 8.2. that although the three middle schools investigated do have a lot of similarities in scores obtained in the various variables, nonetheless real variables have also emerged. In order to try to explain these differences a survey of relevant literature was undertaken and summarised in the next section. The rest of this chapter then describes various aspects of each school which were studied in the research in order to explore possible explanations for the differences.

8.3. Theoretical background into school based research

One of the reasons put forward in chapter 1 for the poor maths performance of many students in the Bafokeng region was the lack of quality teaching in maths classes. There is no generally accepted theory of instruction in mathematics although many attempts to produce such a theory have been made.

In the sixties, classroom research was dominated by a trial and error search for predictor variables but without much success. Gradually there was a change over to systematic classroom observation of the descriptive analytic type and it was hoped this would lead to a basic set of concepts which could be organised and interrelated by theory (Fey 1970, P.1). Fey, among many others, conducted such classroom research by use of a system of analysing protocols from recordings and observations made during maths classes (ibid P.11). The typical pattern which emerged was:

> ... the teacher solicits facts, the student responds with a statement or fact and the teacher reacts by evaluating the student's response (ibid P.73).

Duncan and Biddle (1974) reviewed more than twenty studies in classroom research carried out during the period 1964 to 1973 (P.202). All of these made use of audio and/or visual recordings as well as live observations and included at least six studies which were specifically into mathematics teaching. In the view of these authors the most significant findings have come from research into the verbal moves performed in the classroom. About 50% of all moves are teacher initiated and almost half of the pupils' moves are simply responses to what the teacher says (ibid P.220 ff). This is similar to the findings of Fey (op cit) in his research into mathematics classes quoted above.

In the findings of the present research among the Bafokeng given in sections 8.5. and 8.6. below no quantification was made of teacher moves compared to student moves. However the pattern observed was most often that described by Fey and Duncan & Biddle i.e. teacher solicits ... student responds ... teacher reacts. This would account for approximately half of the moves, other patterns were teacher talks and no student response. What was found to be unique however was the low intellectual level at which this exchange occurred. The subject of the teacher's question was never hypothetical or seeking for broad based strategies. The teacher was generally asking something trivial like "four plus six is what ?"

In the U.K. authors such as Morrison & McIntyre (1973) and Bennett (1976) focussed on the teacher in the classroom. Morrison & McIntyre discuss inter alia styles of management and control exercised by different teachers. One model which has been used ,is that of leadership styles which may be classified as authoritarian or democratic. But this model, they say has not proved adequate for research (ibid P.154). Like their American counterparts quoted above, Morrison & McIntyre say the tendency has been away from the authoritarian-democratic model and towards interaction analysis which relies upon objective recording of verbal acts in classrooms (ibid P.155). The major obstacle to be overcome in this line of research is the lack of an agreed criterion of effectiveness with which to measure teaching styles. The evidence concerning the relationships between teaching styles and pupil achievement they claim has been quite inconsistent up to the present (ibid P.165). At the same time Bennett (1976) was busy with the study of teaching styles and pupil progress. From a cluster analysis of 468 student teachers he produced a typology of teaching styles. These are arranged in a continuum with twelve major types grading from formal to informal (P. 45-47). Bennett reports a stronger effect of teaching style on mathematics than on other school subjects. Most gain is associated with formal styles but he stresses that this is not true for all pupil types (P.137). It was particularly disadvantaged children who seemed to show most improvement in the informal environment (P.137).

In the absence of a pupil typology for Bafokeng students (or indeed an acceptable teacher typology either) it is not possible to apply Bennett's work in the present research. However it does at least point out the dangers inherent in crude generalisations and Bennett has shown that matching of teaching style and pupil style does affect pupils' progress in mathematics.

Bennett (1976) comes out strongly in favour of high work performance on the part of the pupil. This is the single most important factor related to pupil achievement; what is learned depends largely on the activities of the student and the teacher must provide opportunities for a pupil to study a given content (ibid P.158). Other researchers also found a high correlation between work related activity and achievement e.g. Holt (1964) Fleming (1980) Heritage (1980) etc. It was found that the time spent on a task was the crucial factor in attainment especially in mathematics.

In the classroom observations given below in sections 8.5. and 8.6. there was little time spent by pupils working at mathematics by themselves or in small groups. Most of the pupils' time was spent looking at the teacher solving problems. Little homework was given and it did not seem to be consistently corrected. Only a few pupils in each class were observed to be working exercises in their own books while the teacher worked at the blackboard.

It is widely accepted in the literature that attending school does make an important contribution to a child's development particularly in the cognitive domain e.g. Good et al (1975), Husen (1979), Rutter et al (1979). But in spite of a great deal of research there is still little agreement on what processes inside the school contribute to what a student learns. One exception is the work level of the student referred to above. One approach to identifying factors which contribute to student learning is based on the process-product model which is well developed in Duncan & Biddle (1974 P.36-50).

There is also in the literature a lot of criticism of schools and of formal education. Holt (1964) is critical not so much of the school <u>per se</u> but of the way some schools are run and the way some teachers allow their own humanity to be submerged by the requirements of curriculum and examination. He recounts one incident of a child struggling with the seven-times tables and how he, as a teacher, failed to help.

> This poor child has been defeated and destroyed by school. Years of drill, practice, explanation and testing - the whole process we call education - have done nothing for her except help knock her loose from what common sense she might have had to start with (Holt 1964 P.148).

Holt is very critical of tests and grading of children according to their performance on sets of questions devised to categorise them into "pass" and "fail" groups and he advocates mastery learning. What he says is important for the present research which he has found a highly significant correlation between attitudes and the success in mathematics.

Coleman collected data in 1965 in a survey in the U.S.A. and concentrated only on school characteristics. He found that out-of-school factors, especially socio-economic ones are more important for scholastic achievement than what happens inside the school (Coleman 1966 P,22). He also noted that the gap between the attainment of low SES pupils compare with high SES pupils increases over the usual twelve years of schooling (<u>ibid</u>).

Other authors such as Illich (1970) take a more extreme view and condemn the whole notion of institutional schooling. Illich distinguishes between education which is a trait of human kind and schooling which, he claims, is an institution established by society to maintain the status quo. In his view the school system serves a power function in the modern world (P.43). Sharp and Green (1975) concur and they analyse the problems of power relationships within the school and espec· lly the role of the teacher in the social structuring of the pupils' identities (ibid P.23). Paulo Freire (1972) condemns the banking concept of education which he also sees as an instrument of oppression (P. 46 ff). He does not condemn schools necessarily, although in the 1972 book he is addressing himself to adult education programmes for illiterates. He sees education as a liberating force provided it is entered into as a dialogue between teacher and student and provided there is not dichotomy of roles in the educational process (ibid P.54). Since the start of the colonial period formal schooling has come to be seen as desirable in African countries. All the newly independent states of the present century have set the building of schools as one of their major political goals (Thompson 1981 P.33). The current trend, however, in Africa is more critical of the schools. Up to now the need for certification (and hence the pass/fail categories) has dominated the schools (*ibid* P.201). Schools have not served the need of the whole population for example in South Africa, nor has society made any serious efforts to look at the alternative ways of meeting these needs, In Liberia, Cole *et al* (1971) found that in spite of all that was wrong with western type schooling in that country, nonetheless students who had more than three years of suc schooling showed considerable gains in abstract thinking when compared to those who had not attended school.

In Bophuthatswana, the question about the need for schools is an academic one and has not yet been raised among the Bafokeng. The expressed wish of the people is for more and more schools. However it was pointed out in chapter 1 that parents and others are now beginning to question the ability of the school system to provide their children with good jobs. Some of these issues are recently being addressed in the education magazines of Bophuthatswana e.g. *Matlhasedi*, the education journal of UNIBO and *Popagano*, the journal of the department of education. Writing in the November issue of *Popagano* Lehobye (1987) discusses the authoritarian-democratic model of classroom management referred to earlier. He is making a case for small group instruction and he notes that modern youth in Bophuthatswana no longer submit to unqualified authority and one way instruction (P.9). Lehobye's call for a study of teacher types and pupil types reminds one of Bennett's (1976) work in

England. Murphy (1988) describes the styles of teaching in the normal Bophuthatswana schools as "cramming by the students and authoritarian by the teacher" (P.17). Acquath (1987) wrote about problems in maths teaching in Bophuthatswana high schools. He urged that maths lessons must always be of the discussion type and not the lecture type. He continued:

> Maths must not be taught in the fixed traditional way, the teacher must develop his own unique approach and he must encourage originality among his pupils (P.15).

The implications of the foregoing theoretical discussion for the present research are clear. Two possibilities present themselves: either to investigate classroom teaching in the Bafokeng schools along the line of Bennett (1976) or Duncan and Biddle (1974) or else to ignore completely what takes place inside the classrooms and confine the research to the analysis of variables presented in Chapters 7 and 9. The first option was not feasible due to the constrictions of time and finance and the second option seemed irresponsible. Hence a compromise was made. In the research designed in Chapter 5, section 5.2.2. it was decided to focus on the students rather than on the teacher or the schools. Hence in the present chapter the material is presented from the perspective of the student learning mathematics. The schools are described, the inservice training is analysed and classroom observations are made in order to record what was happening to the students. The aim here was to try to find similarities and differences between those who were good at mathematics and those who were not good at mathematics.

8.4. The schools described

8.4.1. (a) Physical layout

all three middle schools are built in the form of an open square with a stoep running along the inside. Mataie is situated in the middle of Phokeng village, Keledi is at the edge of the village about 4 kms in the Rustenburg direction and Mafenya is about 16 kms in the Sun City direction and built in the bush away from any settlement. Matale is about 50 metres from the main tar road on a property adjoining a new O.K. shopping complex; Keledi is about 200 metres back from the tar road on a rocky outcrop but no road noises intrude and the view of Tshufi mountain from the school grounds is very beautiful; Mafenya is about 3 kms from the tar road and about 400 metres back from the gravel road to Chaneng village which is another few kilometres away. The relative positions are given in Fig 6.1.

All three schools are clean and the grounds are tidy but there is little landscaping and while there are some flowerbeds there is no grass or lawn and very few trees.

Because of the location of each school the student enrolment is drawn from different parts of the Bafokeng region. Matale is nearest to the old section of Phokeng and the people living there have a proud sense of identity as Bafokeng. The houses are well built and indicate better off families. This is confirmed by the SES analysis given in Chapter 7 and referred to in section 8.1. of the present chapter. Matale students have a higher SES average score than Mafenya or Keledi. Mafenya might be described as a rural school being situated approx 20 kms from Phokeng and a few kms back from Rustenburg/Sun City tarred road. The SES average for Mafenya is 20 compared to 24,5 for Matale. Keledi is situated at the edge of Phokeng village adjoining some of the poorer sections. Over 20% of the std 7 students live in tin shacks and the SES average is 19,6 which is the lowest of the three schools. As was discussed in Chapter 7 low SES is associated with poor academic achievement and it is not surprising to find performance of Keledi students in the picture problems to be worse than that of Matale and Mafenya.

8.4.2. (b) <u>Classrooms</u>

The classrooms are big and airy with plenty of light. The size of the classrooms is approximately 8m x 7m and the ceilings 3.5m high. The windows in Keledi are large 3m x 2m along one wall, those in Mafenya are smaller and are in both side walls with many broken panes of glass and in Matale there are windows in both side walls but they are very much smaller. The floors in all the classrooms are cement - they are in good repair in both Keledi and Mafenya but cracked and broken in Matale. All rooms have large blackboards 2.5m x 1.2m in good condition. The walls of the classrooms are brick up to 1.2m and plaster above that; all are in need of painting. The ceilings are white and have strip lighting but there is no electricity in Mafenya although the school is wired; the other two schools have electricity. Only Matale has a telephone in the principal's office; the other two schools have no telephone.

Table 8.7. Numbers of rooms in each school:

SCHOOL	CLASS ROOMS	ENROL-MENT	AVERAGE PER ROOM	OFFICE	STAFF ROOM	BOOK STORE	HOUSECRAFT ROOM
Keledi	12	1020	85	1	1	1	0
Matale	10	672	67	1	0	1	1
Mafenya	9	452	50	2	2	1	1

What serves as a staffroom in Matale is a tin shack in the school grounds which was originally a storeroom and scill has a lot of broken furniture and garden utensils, it has no ceiling and it is very hot and stuffy during the summer and extremely cold during the winter season. None of the schools has a library or science room or other special purposes rooms and none has a hall. Assembly takes place in the school yard between the classrooms. There are toilets situated away from the main classroom blocks, in each school; in 1987 these were dry toilets although a start has been made in Keledi to install flush toilets and this work was in progress during the researcher's visits to that school. There are no charts, pictures, maps or diagrams or visual stimulation of any sort in any of the classrooms apart from the class timetable and in one Keledi classroom there is a diagram of a snail on a piece of A4 paper and in one Mafenya classroom there was a 1987 calender on the wall. In each room there is a wall cupboard; in Keledi there are shelves inside and students use them for their books, in Matale the shelves are broken and the cupboards are not used, in Mafenya the cupboards are locked and are used by the teachers for keeping exercise books belonging to the students. The best furniture is also in Mafenya where there are double tables and plastic chairs for each student. In Matale the furniture is double desks, quite a few of them are broken and there are not enough to seat all the students so they are sitting three at a desk. In Keledi it is mostly double desks and there too students have to sit three at a desk. In all rooms there is a teacher's table and chair. To summarise, the oldest building and the one most in need of repair is Matale and it has the worst furniture as well, otherwise the schools are very much the same. Matale students did best in picture problems but the physical layout of this school is least attractive of the three - it is the oldest building, classrooms have smallest windows and most broken panes of glass, floors cracked and in need of repair and worst furniture. There is no proper staffroom and teachers use a tin shack for doing corrections, preparing classes etc. We must conclude that the condition of the building and the state of repair of the classrooms is not a factor in determining success and failure in mathematics at the std 7 level. This finding is consistent with previous research for example Bennett (1976) agrees that although the quality of the environment in which the children work is important, nevertheless its effect may be relatively marginal in fostering learning (P.160).

8.4.3. (c) <u>History</u>

All the middle schools are community schools, built and maintained by the Bafokeng Tribal Authority. Teachers' salaries are paid by the Bophuthatswana Government. The oldest of the three is Matale which was built as a high school in 1945 (Kiely 1983) to serve the Bafokeng region's second level educational needs. In 1963 a new school was built 2 kms away and named Bafokeng High

School, and the old premises used as a hostel for several years. Matale Junior Secondary School was instituted as the demands for secondary education grew in the sixties. Keledi was built as a primary school in 1972 and named Kgale Primary after the location of the building. Mafenya was built in 1975 and began functioning in 1976 as a Junior Secondary school. The first National education commission (Republic of Bophuthatswana 197? P.62) made a proposal to institute a new kind of junior secondary school to be called "middle school" which would have standards 5,6 and 7. The report suggested that the existing junior secondary schools be reorganised accordingly, which meant the transfer of standard 8 classes to neighbouring high schools and standard 5 classes from the primary schools to the new middle schools. The report also foresaw the necessity of converting some of the higher primary schools into middle schools (ibid). The date set for the implementation of this scheme was 1st January 1981. In fact the operation took much longer to complete than the report could have foreseen because of how local people and especially teachers and principals looked on the changes. Existing schools could either be "upgraded" i.e. from primary to middle school or from junior secondary to high school or alternatively they could be "downgraded" i.e. from junior secondary to middle school.

Hence in the reshuffle both Matele and Mafenya lost their junior secondary status and became middle schools whereas Kgale primary was "upgraded" and became Keledi Middle School.

It is clear from the brief history presented above that the three middle school have very different backgrounds. Matale has a long tradition and served Phokeng as the only secondary school for more than twenty years; it lost its secondary school status in the eighties but maintains its aura with the local people. Mafenya was built in the countryside to serve the needs of Chaneng in the capacity of a junior secondary school and it is very highly thought of there. Keledi has only recently come into the picture and it was only in 1985 that it entered its first group of candidates for the standard 7 public examination Very little change was made in the staff of any of the schools and so in Matale and Mafenya the teachers had been used to secondary school work. For a long time the teachers in Keledi were all primary school teachers with no experience of secondary school work. The National Education Commission made certain suggestions to deal with this particular problem as discussed in the next section below. By reason of its history as an upgraded primary school Keledi would tend to be least well able to handle secondary school classes. There had never been secondary school students attending there and the teachers and principal had no previous experience of secondary school work. By comparison Matale was for almost 20 years the site of Bafokeng High School and some of the traditions have lingered on. Mr Pitsoe, the man who was principal of Matale during the change over from secondary to middle school status had been himself deputy head of Bafokeng before being appointed principal of Matale. It seems then that Matale school was well able to cope with secondary school students due to many years of practice. Mafenya had been built as a Junior Secondary school and the principal and staff were experienced in teaching students up to std 8 level, therefore they would not have experienced anything new when Mafenya was converted to a middle school. Morrison and McIntyre (1973) discuss differences between primary and secondary schools which would support the findings given above. Primary schools are child centred, secondary schools are more subject centred; primary teachers tend to be less formal and direct in their teaching styles, secondary teachers tend to be more formal and authoritarian (P.157). This may help to explain how Keledi students differed from the other two groups as a result of the traditions associated with primary teaching inherited by the teachers of that school.

8.4.4. (d) <u>Relationships between the teachers</u>

This is a delicate issue in any school and a difficult one for an outsider to probe. In talking with the principals it became clear that they generally used two criteria when forming an opinion about one of their teachers: knowledge of mathematics and how the teacher gets on with the students. In M'tale the relationships between the principal and the maths teachers seems to be good and there was no indication of jealousy or rivalry between the mathematics teachers themselves. These teachers seemed to be respected and left alone. In Keledi one of the teachers was described as very good because he knew his mathematics and got on well with the students, a second one was still new in the school but had been spoken very highly of by her former principal while the third was seen as something of a problem since "she knows mathematics alright but doesn't get on well with the students". In the researcher's own experience of secondary school teaching in the Bafokeng region this is a very serious matter and has sometimes led to school riots, burnings, boycotts and dismissal of teachers. All of these are important for any principal in the running of a school ! In Mafenya there was only one full time mathematics teacher for the standard 7 classes but she was a young female and relationships between herself and the departmental head were not good. The senior male teachers in the school did not have much confidence in her. Several of them had experience of teaching mathematics or at least arithmetic and they felt she was not doing things properly. Some of the things which had upset the mathematics teacher were the changing of examination questions without consultation and the bringing in of a matric student to teach the Geometry section of the standard 7 syllabus. The most stable relationships were recorded in Matale and the worst in Mafenya, Keledi had good and bad.

Taking these observations in conjunction with the history from (c) over leaf it seems Keledi is suffering from inexperience on two counts: one the school authorities are unable to prevent gross overcrowding in the way Matale and Mafenya can and secondly Keledi teachers use different standards both for promoting and for passing students in their internal exams than do Matale and Mafenya teachers. The researcher has noted that in the secondary schools the public examinations tend to dominate many aspects of school organisation and especially the pass and failure rate and consequently the promotions and the number of years students repeat classes. Teachers try to protect themselves from public and education department criticism by controlling the number of students sitting for the public examinations and only allowing through, those students whom they think have a reasonable chance of passing. From the teachers' own experience of these exams most students would fail if a policy of one year one class was implemented and hence the high failure rate and the large number of repeaters in every standard below that in which public exams are faced. When the June 1987 exam results are examined it is clear that the sample interviewed in Chapter 6 does not represent the lower half of each class of students.

Table 8.8. Students from each quartile interviewed; based on June exam results.

SCHOOL	SAMPLE INTERVIEWED				T
	1st quartile	2nd quartile	3rd quartile	4th quartile	
KELEDI	19	6	5	2	
MATALE	12	2	1	1	
MAFENYA	5	1	3	3	
TOTAL	36	9	9	6	

It can be seen that the sample is heavily weighted in favour of the average and above average students. 60% of the students interviewed are from the first quartile - the reasons for this were explained in Chapter 6.

8.5. Inservice training

The importance of teachers in the education system of Bophuthatswana has long been recognised as can be seen from the treatment given to this matter in the first national education commission report which devotes a whole chapter to this topic (Republic of Bophuthatswana 1978).

> It has been brought forcibly to the attention of the Commission throughout its sittings that whatever the aspect of education it might be discussing at any particular juncture it has always come back to the teacher. The character, personality and professional competency of the teacher are always the key to the problem or situation that is being discussed. Proposals for a new structuring of education, amended curricula, revised syllabuses, necessary as they are, will be of little avail and will remain recommendations on paper without the complete commitment of the teacher to their implementation in the classroom. The whole machinery of education from head office down to the inspector and the local authorities concerned with the school, exists not for its own purposes, but to enable the teacher to do an effective job of work in his everyday face-to-face contact with children in the teaching-learning situation. (<u>ibid</u> P.74).

Elsewhere the report gives figures to show there had been a five-fold increase in secondary school enrolments from 12,328 in 1969 to 64,650 in 1977. But there was no corresponding increase in the number of qualified teachers and the report says:

> Summing up: there are not sufficient graduate teachers to provide even a principal for each of the schools engaged in secondary work; one-quarter of the teachers have academic qualifications of standard 8 or lower; only one-third of the teaching staff are professionally qualified to take secondary school subjects (<u>ibid</u> P.78).

Commenting on the larger R.S.A. scene, Professor White speaks about the same problem of poorly trained teachers and he saw a two-fold task facing those involved in teacher education namely to provide massive in-service upgrading courses and to increase greatly the output of trained teachers (White 1983, P.240).

In Bophuthatswana the first national education commission report recommended the setting up of one strong in-service organisation, the use of teacher training college staff so that all teachers have regular courses, workshops etc. (Republic of Bophuthatswana 1978, p.87). The programme for upgrading teachers consisted of two parts (a) academic, which meant in practice providing courses to enable those te .ers with only standard 8 certificates to matriculate and (b) professional, five-day live-in courses in specialised subject areas like mathematics, geography etc. Sponsorship was secured for both kinds of courses and the plan worked well in the early eighties. However the funding eventually ceased, at least for the matric classes and round about the same time there was a noticable fall off in the subject courses as well. Instead of having, for example all the mathematics teachers attend special live-in courses, only one or two from each circuit attended these courses in 1987 and they were then expected to conduct courses for the other teachers in their respective circuits. While this sheme must undoubtedly have saved a lot of money the burden laid on the selected teachers was very heavy.

In the Tlhabane circuit these teachers had to do all the organising, secretarial work etc. themselves in their own free time and sometimes bear the cost of travel, stationery, postage from their own pockets. The present researcher attended one such course for high school mathematics teachers held at Alpha Centre in 1987. There was no money payable from any of the 30 teachers who attended - two from each circuit in Bophuthatswana; the sponsorship covered the food and accommodation at the centre and the expenses of the lecturers. Travel costs were met by the schools. There were lessons given in the new sections of the standard 10 syllabus. There was no time allocated for discussion of the new sections or whether teachers thought they were appropriate for their students or not. There was no training in how to organise other mathematics teachers in the circuits other than the instruction that it must be done as soon as possible. In September 1987 as a result of a similar week-long course for middle school maths teachers a two day mathematics seminar was held on the 1st and 2nd September 1987 for all standard 7 mathematics teachers in the Tlhabane circuit. The programme was circularised to the schools just one week beforehand and a number of high school mathematics teachers were invited to assist. The programme planned for the seminar is given in Table 8.9. It can be seen from this table that there was no time set aside for discussion of teaching methods and the stress was on mathematics content.

Table 8.9. Programme for middle school mathematics course:

DATE	TIME	TOPIC	LECTURER
Sept 1	8.00 to 10.00am	Statistics	Middle school maths teacher
	10.00 to 10.30am	Breakfast	
	10.30 to 12.30pm	Euclidean Geometry	High school maths teacher
	12.30 to 13.30pm	Lunch	
	13.30 to 15.30pm	Factorization	Middle school maths teacher
Sept 2	8.00 to 10.00am	Linear equations	High school maths teacher
	10.00 to 10.30am	Breakfast	
	10.30 to 12.30pm	Word sums	High school maths teacher
	12.30 to 13.30pm	Lunch	
	13.30 to 15.30pm	Letter symbols	Middle school maths teacher
	15.30 to 16.00pm	Year plan for maths courses for 198	

During the course the mathematics organiser from the in-service office attended some of the lessons and had informal discussions with the lecturers. Some points raised were the purchase of reference books for these kinds of courses, the payment of travel expenses etc. While he listened politely and included these items in his report nothing was ever done about it.

This course was attended by 17, which is just over half of the standard 7 mathematics teachers in the Tlhabane circuit. The expectations of all the attending teachers were very high and in general they hoped it would help improve the pass rate in mathematics at the standard 7 examination. A breakdown of the lesson on statistics is given below as a sample of what happens at these sessions. This material was recorded by the researcher during the presentation of the lesson. The lecturer introduced the day's programme after a prayer and a hymn and then said that the first lesson would be a review of the standard 6 work on statistics. He used English through the lesson and all answers etc. were in English, however during a 15 minute interruption when there was a discussion about food for breakfast and lunch, only Setswana was used. Four topics were covered as follows:

topic 1: pictograms and scales .... 20 minutes
topic 2: Bar charts and tally charts .... 25 minutes
topic 3: Pie charts and proportion .... 18 minutes
topic 4: Line graphs .... 16 minutes

There was no introduction to relate statistics to anything else either in the mathematics syllabus or in the world outside of the classroom. The lecturer took an exercise from the text book to start with and illustrated it on the blackboard and asked aloud the questions exactly as they were written in the text book and this was the pattern throughout the whole lesson, moving from one question to the next in the text book; in fact the only time the lecturer left the text book out of his hand was when both hands were required to draw something on the board. The following extract from the transcript concerns the teaching of bar-graphs:

> Lecturer: Now a bar-graph like it says consists of bars. Hence we wish to represent data concerning attendance on certain days (he refers to a question in the text book, all the teachers look at the text book briefly). There are certain points we must note: point one, width of bars must be the same; point two, width of spaces must be the same but not equal to the bars; point three, we must label the axes; point four, the graph must have a title (lecturer turns to the blackboard). Hence I wish to represent one bar graph (lecturer proceeds to draw lines on the board using data from one of the questions in the text book but doesn't say which one. All the teachers are looking and trying to find out which question the lecturer is dealing with. There is no talking during this time - over four minutes). Now we see width of bars are equal, width of spaces are equal, we have labelled the axes and given the graph a title (lecturer reads the questions, one at a time from the text book and the teachers answer in chorus). No problem until he reaches the question: How many periods are there per week? No answe ... No help other than repeating the question ... eventually someone says "48" and the lecturer says "correct, now do you all see the answer is 48?" chorus "yes".

There was no explanation of how to do the questions or how to teach words or how to build up concepts. When the lecturer was treating pie-charts he introduced it as follows:

> Lecturer: "This diagram is called a pie-chart because it looks like a pie, whatever that may be and I have never seen a pie so there it is."

The lecturer and, presumably the teachers, had not associated the pie-chart in the text book with the meat pies which are sold in the shops. Another example of how isolated from real life experience this lesson was became evident when dealing with tally marks as a method of counting frequency. The lecturer told the teachers that in statistics "there is a special method of representing data, like for example in this question" (he reads a question concerning soccer, tennis etc. from the text) "we have tally marks to show the number who play each game" (he reads instructions from the book on how to fill in the tally marks, even the instruction about drawing a line across four little lines to represent 5). There was no reference to tally sticks used by some herdsmen to count cattle or to anything outside of the textbook.

At least six of the 17 teachers present were unable to draw simple linear graphs but when the lecturer dealt with line graphs the only thing he did was to work quickly through some examples taken from the text books by drawing these on the blackboard and asking what does each arrow represent. In one such example the lecturer's explanation consist d of the following two statements:

> "Here 10 divisions represent 100 and 20 divisions represent 200. Now that place mark of the arrow what does it represent?" chorus answer: 120. Lecturer says "correct because each division represents 10 and so we get the answer."

This item is important because of picture problem number 4 which was used in chapter 6 for interviews. The teachers had no teaching about this topic during the inservice course and one must conclude that they would present the topic to their own students in the manner in which they themselves learned it during this ccarse.

To summarise, it appears that during the inservice courses there is little or no attention paid to the teaching of new words or the building up of new concepts. There is no linking of the mathematics material to the real world and no use is made of the lived experiences of the participants. There is no reality testing and no checking of answers other than authority of the lecturer. There is no recognition of perceptual problems which might or might not exist among the students. Finally there is no time for fundamental thinking about how to approach a given problem, the lecturer explains to the class how the problem must be solved and he makes all the important decisions, the role of the participants is reduced to answering - often in chorus - trivial questions like what is the answer for 7 plus 15.

After the lesson described above was completed the researcher asked a number of participants for their evaluation and in all cases they expressed complete satisfaction: "It was f : and I found it very useful" ... "It was excellent because previously I wasn't clear about pie charts and now it's clear" ... "I could follow everything because of its simplicity" ... "I will teach it to my students exactly like that with some improvement if possible and my students will know it well".

8.6. Observed Lessons

As a follow up on the inservice study described above it was hoped to observe the standard 7 maths teachers each conducting a lesson in their own schools on the topic "statistics". The purpose of this was to learn what influence the inservice courses had on the teachers' class presentation. It was hypothesised that the manner in which the teachers taught mathematics greatly affected the good or bad performance of the students in the five picture problems of chapter 6.

Much work has been done on the field of classroom research eg., Woods (1980), Rutter et al (1979), Good et al (1975), Duncan & Biddle (1974), Bennett (1976), Morrison & McIntyre (1973). No attempt was made in the present research to analyse teaching styles or to correlate students' maths performance with teaching style; what the researcher did was simply to sit in on a maths lesson in the capacity of one maths teacher observing another maths teacher in action and recording what he saw. It proved impossible to have all teachers present a lesson on statistics because they claimed they were very far behind in the mathematics syllabus and were rushing to complete the year's work before the final examinations. In all, six mathematics lessons were observed as follows:

SCHOOL	STD	TOPIC
Keledi	7A	Geometry theorem: the sum of the angles of a triangle is 180 degrees
	7B	Algebra: simple equations with one unknown
	7D	Algebra: simple equations with one unknown
Matale	7B	Ratio and proportion
	7D	Ordered pairs and linear graphs
Mafenya	7A	Statistics: frequency distribution

The researcher visited the schools for the observations having first made arrangements with the principal and teacher concerned. None showed any hesitation about allowing the researcher into their mathematics classes and there was no evidence of stress on their part during the lessons.

No report was asked for by any of the teachers and no report was given. The researcher made detailed notes during the observation lesson on everything said and done by the teacher and by the students. There were several good features common to all six lessons. All the teachers had the material very well prepared, there were no mistakes in the mathematics. Each one knew exactly what he or she was doing in the lesson and did it competently. It was clear that each teacher was experienced in dealing with the subject matter. All the lessons were based directly on the syllabus and the teachers used only examples which were available for all the children to study because they were from the textbook. Discipline was good in all the classes even where there were up to 80 students present. No corporal punishment was used. The students were co-operative and respectful all the time and the spirit of work in the classroom was good. Naturally it was impossible to say how the researcher's presence influenced the classroom atmosphere but there were no signs of "putting on a show" for the visitor.

Those features which the researcher regards as being "bad mathematics teaching" and which were observed in the lessons include (i) lack of homework (ii) no individual practice (iii) making decisions about general approach to problems (iv) new words and concepts (v) integration with previous knowledge (vi) checking answers. One lesson of the six observed was quite exceptional in the sense that hardly any of these criticisms applied to this lesson and while all the other lessons were dull and uninspiring, this lesson was lively and exciting.

(i) In general there was no evidence of homework done or controlled on a systematic basis. Two of the lessons started with the teacher discussing homework, the other four lessons had no reference to it although four of the six teachers gave the students specific work to do as "homework" at the end of the lessons. It is the experience of the researcher that homework control is a serious problem in the schools in the Bafokeng region. Unless the work set is collected and marked by the teacher then it simply is not done by the majority of the students. Teachers with very large classes are unable to cope with the sheer volume of corrections which this entails. In the two instances where the teacher did start the lesson with reference to homework the pattern was like that described in the following extract from the transcript of one lesson.

> There were 72 students present at the start, a few others arrived late. The teacher told the class to open their homework, a few students had it done but most had no copies in front of them and presumably hadn't done any homework. The teacher showed the class how to do the questions on the board. Most students paid attention to what the teacher was doing but not all. They answered questions like "three divided by three?" .... in chorus. The teacher did not go round the class to see who had and who hadn't done the work and simply told the students to correct their own work from the model on the board. This took five minutes.

(ii) There was no opportunity during any of the lessons observed for the students to practise working by themselves or in small groups. At all times the whole class was engaged in the same activity which was usually following what the teacher was doing on the blackboard and occasionally watching another student working at the blackboard under the guidance of the teacher. Apart from that the only other activity of the students was chorus answering of simple questions asked by the teacher. In one class where the topic was "equations" there were 44 students present and having revised the general formula for the equation of a line by asking "the general equation is y equals what?" and getting a chorus answer "mx plus c" the teacher continued:

> Now the lesson for today is finding the equation of the line (teacher writes ordered pairs (-2;-6), (0-0), (2;4) on the blackboard). We only have to use two pairs (he points to the ordered pairs) we can use this and this, this and this and so on. We have the general formula y = mx plus c. Lets take the ordered pair (-2;-6), what do we call the first component? (he points to one child who answers "x component") and what do we call the second component? (he points to another child who says "y"). Now what is the x component? and the child answers "-2" and the y component is what? "-6". The teacher then repeats these questions and addresses them to the whole class who answer in chorus. The teacher now shows how to get the value of c by substituting -2 and -6 in the general formula and then continues using the second ordered pair (0;0). During this time which takes 2 and a half minutes the class is silent, only six students have exercise books open in front of them and of the six only three are busy writing in their books.

(iii) The method of tackling any problem was always given by the teacher. For example in the geometry lesson the teacher started by writing:

> "ANGLES OF A TRIANGLE" on the blackboard then under it wrote "THEOREM 4" and under that "The sum of angles of a triangle is 180 " and then said to the class "we are going to prove this theorem". The teacher then made a triangle on the blackboard, labelled it and wrote the words "Given, RTP, Construction" under each other. The teacher asked the class "what must we do?" two students raised their hands but the teacher simply proceeded with the construction by extending one side of the triangle and gave a running commentary on what she was doing. When the teacher was doing the proof she asked questions such as "we must have statements and what?" to which the class answered in chorus "reasons". In another lesson in algebra the questions asked were: "6 + 0 is what?" "2m is equal to 6, what is the value of m?" "x over 6 equal to 2,x is what?".

In the statistics lesson the teacher built up a tally table on the blackboard with the help of the students -

she asked some individuals questions but usually the students answered in chorus. All the thinking was done by the teacher, the pupils worked strictly under her direction - adding or counting as they were told:

> Now we will represent the data on a histogram (this was the teacher's idea) but first we must have the class boundaries. A class boundary is the middle value of the end values we have here (teacher pointed to the tally table) what is the number that comes before 20? (class chorus: 19) what is 19 plus 20? (class chorus: 39) divide 39 by two - two into three goes? (class chorus: 1) and two into 19 goes? (class chorus; 9) and what is over? (class chorus: half) now we are going to construct our graph here.

We see from this extract, which is typical of the lessons observed, that the students were only concerned with simple arithmetic and were not allowed or encouraged to do the basic thinking of how to work a problem or even to identify what the problem was.

(iv) There was no effort to teach new words or concepts, for example in the previous extract the teacher simply told the students that a "class boundary" (and this seemed an important concept for the work in hand) was "middle value of the end values". In the geometry lesson when giving reasons for angles being equal teacher asks "why?" and gets the answer "alternate" or "corresponding" and she simply writes down these words beside the statement. The only explanation given was to draw a diagram in another part of the blackboard and pointing to two angles say: "these angles are corresponding".

(v) None of the teachers made any effort to link the lesson material with previous knowledge and there was no planned organisation or adaptation of the subject matter in a Piagetian sense. If assimilation and accommodation did take place (chapter 3, section 3.2.3.) then it was purely accidental on the teacher's part. There was a lot of reliance on rules of thumb and the promotion of instrumental rather than relational learning as was discussed in chapter 3 section 2.3.4. During one lesson the following "rules" were quoted by the teacher several times during the lesson:

> With positive and negative numbers you don't add them but you subtract them and the sign is the sign of the bigger number... In solving the equation you jump this number over to that side and the sign changes..

(vi) The authority of the teacher was the only manner of testing the rightness of any answer. If the teacher said it was correct it was so and if the teacher said it was wrong then another answer had to found and so on until such time as the teacher said it was correct. For example here is an extract from the lesson on ratio and proportion:

> The teacher had written on the blackboard: 3, 6, -, 12, - and asks for the missing numbers. One student answers "multiples of three" and the teacher replies "no" and looked around for another student to answer. This time the student asked said '15" to which the teacher replied "no" and looked for another answer. Eventually one student said "9 and 15" and the teacher said "yes that is correct", and then moved on to the next part of the lesson. In the lesson on equations after 12 minutes work (mostly by the teacher) an equation y = 3x is arrived at and written on the blackboard. The teacher then announces "this is the equation we are looking for". No effort was

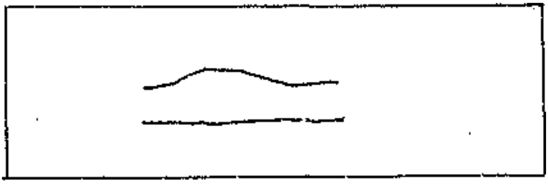
made to check by putting in the ordered pairs which were given in the first instance and for which the equation was supposed to be the answer.

If we think in Skemp's terms of intelligent action, as being goal directed enabling one to move from a perceived present state to a desired goal state, then only the teacher could be said to be engaged in such activity throughout the lessons which were observed. The students were not given time to grapple mentally with the questions to find out for themselves what data was given or to examine what was required to be done in the questions given.

There was one lesson which did not fit into the pattern described in the previous pages and was different from the other five in the manner of checking answers, making decisions about general approach to problems, teaching of new words and integration of new knowledge. A few extracts from the transcript of this lesson will illustrate these points:

In this lesson we are going to deal with Equations (teacher writes this word on the blackboard) and from this word we get another word Equal, (the teacher invites two girls to stand in front of the class and has a lively discussion about "equal" and distinguishes between "the same" and "equal" by referring to their height, their ages, the amount of money they have and so on. The teacher has prepared a flannelboard and cut-outs for this lesson and one card has an equals sign with two lines roughly drawn as shown in Fig 8.1. The teacher says this sign means "equal" or "similar" or "the same as".

Fig 8.1. <u>Illustration of "equals" sign</u>



One student, a girl, objects that this sign is not correct because one of the lines is longer than the other one. The class enjoy this joke and so does the teacher).
The teacher invites the students to make an equation using cut-outs and eventually the students arrive at the arrangement shown in Fig 8.2.

Fig 8.2. <u>Equation built up using cut-out cards</u>

The teacher then says: "The question is what does the letter "x" represent?", he pauses and the students are busy talking to one another about the problem. Then the teacher continues: "There are two ways of finding "x" - just look at it and see that some number has 6 added to it and the result is 17" (there is a forest of hands up and one student says "it must be 11" (the teacher shows that when the letter "x" is replaced by the number "11" the statement is "balanced" and explains:
"we have the left hand side always equal to the right hand side, that is what is meant by "balanced". The teacher now says: "the question is how does that boy get "11"? let us ask him, the boy tells the class: "I subtract 11 from 17" the teacher then addresses the class: "this boy has his own reasons for what he says, how would you do it yourself?" ... pause while the students consider this ... another boy explains: "11 plus 6 is 17" ... another girl says: "I start with 7 and I count up to 17" ... the teacher makes a number line on the blackboard and asks the girl: "which is the starting number?" ... the girl replies: "7" and the teacher counts with her from 7 and shows that would give an answer 10 not 11, the girl sees

that it is not correct and says "no it should start at the number next to 7 and not at 7".

This lesson as can be seen from the above was one in which there was real thinking on the part of the students and checking answers was not dependent on the teacher but was shown to depend on the internal consistency of numbers and the operations done using these numbers. No claim is being made here that what constitutes good teaching for one teacher automatically is good for every other teacher. It would be very easy to slip into such a false assumption but that is not the point being made in the above extract. Bennett (1976) makes a plea for a variety of teaching methods to suit individual differences between students (P.10). He states there is no single best way of teaching although the implicit assumptions in many studies of classroom behaviour is that there is one best way of teaching everything to everybody (P.18). Professor White has given the basics of what is required in any "competent teacher" as quoted below in 8.8. (White 1983). How an individual teacher applies these skills depends on his or her own teaching style.

8.7. Diary of a middle school mathematics teacher

The researcher is responsible for student teachers doing teaching practice in Bafokeng High School and an opportunity presented itself in 1987 to deal with some who were doing their practice in the middle schools. The researcher asked one of these student-teachers who was doing mathematics for two weeks to keep a diary of his experiences. The notes made by this student-teacher are very revealing and describe how one teacher was able to transform a class from "hating mathematics" into a class which "during study time most of them came to me with pieces of paper with maths problems to correct them". (Appendix A No. 4)

The way this change was brought about according to hiself was two-fold:

(i) When a difficulty was experienced then the teacher identified the concept which was lacking or not fully understood and he took time to teach it using objects where necessary. This is seen in the following extract:

> The previous day I introduced the square root idea to them and I did a lot of talking in explaining the square root and how to find it but most of them were left in the dark. When I realised this I decided on the following day to let them play a game by collecting some stones. Each started with four stones and then they made squares and they soon learned what a square is and what is a square root (Appendix A No.4).

(ii) The teacher really liked the students and he promoted positive attitudes towards mathematics. This enabled the students to experience success and their self-image was affected. The result of this was an interest in mathematics and the students now began to enjoy mathematics and to practise it on their own.

> I have been giving two mathematics lessons today and I was impressed by the response of the pupils com-

> pared to the first day I went to that class. What I realised during my first day was that the pupils were not free in the class during the mathematics lesson. So I started creating a good lesson atmosphere with the result that they are now happy when I come to class. They are free to participate and they know I am there to help them and if they don't understand they should come to me and there is nothing wrong if they have a difficulty in mathematics. Now the pupils seem to enjoy the maths lesson (ibid).

This extract shows that all is not lost for the present generation of middle and high school students and that they need not necessarily be doomed to failure in mathematics as indicated by their poor performance in the public exams. It has sometimes been said that it would be a waste of resources to try to remedy the lost cause of middle and high school mathematics, and that it is better to use whatever resources are available to build up a new system from the lower classes in the primary schools.

This researcher thinks that an expanded in-service programme using the expertise in the schools of each circuit could bring about the necessary change and improve mathematics teaching and learning dramatically. One essential component would be a resource centre, which could be accommodated in one of the existing schools. In this centre materials could be developed in workshop situations as well as providing books, teaching aids, films etc. for use in the schools.

8.8. Summary

The difficulties experienced by the group of "poor" maths students can be traced to the bad teaching observed in the std 7 mathematics classes. Many of the mistakes made and the uncertainties of this group when working with the five picture problems in the interviews result from the manner they have been taught mathematics. There was no consistent policy regarding homework, not enough individual practice of doing mathematics problems, little opportunity for the students to make decisions about how to work a question, no teaching of concepts, no integration of subject matter with previous knowledge and no checking of answers. However it would be foolish to suggest the remedy will be found in giving the teachers a few new skills and techniques, the problem runs much deeper than that. The whole system is at fault, not just the overcrowding, lack of facilities etc. but the whole approach to teaching, the attitudes of the teachers to the students and to the subject matter is what needs overhauling. Professor White lists the minimum requirements for a professional teacher as:

> adequate levels of understanding and skill ... ability to encourage others to begin work and to persist in it until intrinsic motivation takes over ... ability to assess prior knowledge ... adapt teaching to students' rates of progress ... adequate command of the language ... ability to assess progress ... (White 1983, P.234).

The material presented in this chapter shows that this description does not match the reality in the schools.

In chapter 3 two mathematics projects were discussed namely the Caribbean maths project in section 3.4.2.1. and the Lesotho work card project in section 3.4.2.2. According to the evaluation of the latter project the Lesotho work card project failed because it was imported - not just the materials but organisation and assumptions as well. The teachers were only required to implement a fool-proof scheme. But teachers are people and people think and the Lesotho teachers were not expected to think and the project failed.

The Caribbean maths project on the other hand succeeded because, it is reported, the teachers were involved in the development of materials as well as in their use as teaching aids. This helped to build up positive attitudes towards the project and to take on responsibility for what they were doing. They were teaching something which they themselves had helped to create.

In his visits to the schools this researcher found a self-image common among the teachers as one of being an implementer only. These teachers are expected to teach what is in the syllabus according to the manner it is presented in the textbook. All that is expected of them is to produce good mathematics results in the standard 7 public examination. One final thing which emerges from the study of school variables and that is that nothing was unc.vered in the schools which would explain why the "good maths students" are able to perform so well in the five picture problems compared to the others. In the next chapter personal variables will be studied in order to shed more light on why some students do succeed in mathematics in spite of everything described here.

CHAPTER 9

PERSONAL VARIABLES

9.1. Introduction

In this chapter certain personal variables were investigated to find out what relationships they have with mathematics performance. Just as in chapter 7, both std. 7 examinati... results and performance in the picture problems were used as criteria of success and relationships between each criterion and the personal variables were analysed.

The literature abounds with material which may be loosely termed "student traits" to quote Schiefelbein and Simmons (1978, p.8). The I.E.A. was a seven year study in twenty-three countries which examined student achievement in six subjects. Some 500 independent variables were postulated. These variables were grouped into four blocks one of which was students' characteristics such as age, sex, quantity of homework done, motivation and attitudes (<u>ibid</u> P.38).

Alexander and Simmons (1975) analysed eleven studies, carried out in poor countries, which used the educational production statistical technique as a research design. This involved a classification of variables into (a) input variables and (b) output variables. The weakness of this technique is that there is no definite agreement among researchers as to what constitutes an input variable as opposed to an output variable. One example which these authors refer to is that of attitudes and they point out that while they treat attitudes as an input variable and consequently measure its effect on student achievement it could just as well be regarded as a school output. Individual characteristics listed by these authors include motivation, expectations, perceived control over the environment (ibid P.8), age and sex (p.14), need of achievement (p.17), students' self esteem (p.21).

Schiefelbein and Simmons (1978) reviewed 26 research studies done on student achievement which considered student traits as the possible determinants. It was expected these student traits would have a significant impact on achievement and this was borne out in most of the research reviewed (ibid p.11). Four of the 26 studies were from African countries and they showed the following variables to be significant determinants of achievement: socio-economic status, grade repitition, malnutrition, age, health, sex, intelligence, self-concept, family size (ibid p.37). However the same authors point out that some of the attributes like self-concept have not been adequately studied in their relation to student achievement and the authors suggest further research is required in these areas (ibid p.31).

For Minkowich et al (1982), studying achievement of Israeli children in primary school from different cultural backgrounds, the personality variables studied were motivation, attitudes and self-concept (p.160).

Lester (1983) reviews research done on mathematical *problem solving and speaks about the highly* individualised personal nature of problem solving. He claims that until the late seventies little progress had been made because there was no agreement on what the key variables are that influence behaviour (Lesh and Landau 1983, p.230). Kruteskii (1976) decided that only those characteristics related to cognitive behaviour should be studied and he classified problem solvers according to the types of mental processes they used.

It was decided not to neglect cognitive variables but to follow the main body of research in poorer countries which deals with personality characteristics like motivation and attitudes of pupils and self-concept as well as age, sex, homework patterns etc. in the present research.

The variables selected for analysis in the present study of success and failure in mathematics among the Bafokeng were therefore: (i) self-concept (ii) attitudes to mathematics (iii) age and sex (iv) cognitive behaviour and (v) other variables such as homework patterns, English language fluency etc. Each of these is dealt with in the following sections.

As mentioned earlier the concept "success in mathematics" was the subject of chapter 2 and two criteria were proposed. In chapter 7 an attempt was made to use the maths exam results to calculate correlations of the two home variables socio-economic status and culture on the one hand with maths exam marks on the other hand but there were no significant correlations. However when the performance in the picture problems was used as the criterion of success, a strong positive correlation was revealed. In this chapter the same procedure as was used in chapter 7 was followed for each of the personal variables. First the measuring instrument is described, its construction, scoring, as well as reliability and validity. Second the results are presented and discussed. Third, correlations with maths marks and performance in the picture problems are given. Fourth, where possible, further deepening of the investigation is carried out and described. Finally how the particular variable under consideration contributes to our understanding of mathematics learning among the Bafokeng is analysed.

9.2. Self concept

9.2.1. Background

In the pilot study reported in chapter 4, section 4.9. the exploratory work on self-concept was described. In spite of the small numbers involved a considerable amount of useful data was gathered which helped to differentiate between successful and unsuccessful maths students. All the indications were to the possibility of a strong positive correlation between self-concept and achievement in mathematics for the middle school students of the Bafokeng region. A brief introduction to the idea of self-concept as it developed historically is given here and the general findings of the research into the relationship between self-concept and scholastic achievement is reported.

Over fifty years ago Mead (1934) proposed that a child forms various pictures of himself as a result of his interactions with significant others and the child can have many "selves" such as "home-self", "school-self", "play-self", etc. (Siann and Ugwuegbu 1980, P.72). Modern psychology refers to this development of self-image through social interaction as "symbolic interactionism". Significant others have expectations of what a person should do and should not do and the child learns this through social interaction (Jordaan & Jordaan 1989 P.684). Other mechanisms whereby a child comes to form a self-image have also been identified and these include self-reflection and observation of one's own behaviour.

Differentiation theory describes how a child begins to distinguish himself from the environment. Witkin proposed that early socialization experiences can hamper or foster achievement of seperate autonomous functioning

(Witkin et al 1971 P.11). Brinkman (1966), Wober (1967), Okonji (1969), Bishop (1983) among others investigated how child rearing practices and environmental factors influenced a person's perception of himself in relation to outer reality as was discussed in chapter 3, section 3.2.5. Gordon (1975) suggests differentiation is based on Piaget's developmental stages in which he recognised the importance of maturation, as was discussed in chapter 3, section 3.2.3. As the child moves away from egocentricity he begins at the same time to form a self-image. Definitions of self-image remain fairly vague. Jersild (1952) defines the self in terms of an inner world:

> The self constitutes a person's inner world as distinguished from the outer world consisting of all other people and things (Siann & Ugwuegbu 1980 P.73).

Gordon (1975) analyses self-concept into how a person conceives of himself, how stable is this image and what effect it has on behaviour (P.336). In a very detailed study carried out by Minkowich and his fellow workers on student achievement in Israel the self-concept was broken down into eleven items: locus of control, anxiety, general self-image, scholastic self-image, expected maths marks, perceived affection, interest in studies, level of aspiration in studies, importance attached to significant others, attitudes towards teacher, class and school, concepts of the ideal pupil (Minkowich et al 1982, Pp 164-188). It seems therefore that the modern view is that self-concept is a composite of ideas, attitudes, feelings etc. which condition how a person experiences himself and which help to direct his actions. For the purposes of the present research self-image or concept of self will be taken simply as a person's view of himself, i.e. who a person thinks he is and not necessarily who he really is as judged by any other criteria.

The existence of a positive correlation between self concept and achievement is well established in the literature e.g. Coleman (1966), Minkowich et al (1982), Stein (1971), Gordon (1975). But many researchers point out the lack of real understanding about the nature of the relationship and they emphasise that it is not possible to determine which is the cause and which the effect (Minkowich et al 1982 P.165).

Gordon (1975) refers to work done by Stein (1971) in the U.S.A. in which he studied sex-role identification as one item in self-concept. He found significant differences in certain subjects but not in mathematics. Stein concluded that sex-role identification does influence achievement in certain subjects but not in mathematics (Gordon 1975, P.345). Stein's work is important because it sheds light on one of the complications that has been, according to Gordon, neglected in the usual correlational studies of self-concept and performance. The complication referred to is the nature of the relationship. This has led in turn to false conclusions about the real relationship between self-concept and performance (<u>ibid</u>). Elsewhere Gordon states:

> ... the pattern of the relationship between self-concept and achievement seems clear. There is a relationship between positive self-concept and high achievement and negative self-concept and under-achievement ... the chances are we can see a circular pattern beginning earlier with perception of experiences as "successes" or "failures" leading to a development of a concept of self which in turn influences both the selection and evaluation of subsequent experiences. (Gordon 1975, P.393).

The same pattern of positive correlation is identified by Siann & Ugwuegbu (1980), who quote (a) McMichael's (1977) study of Scottish children which established that low self-concept was related to poor reading ability and (b) Samuels (1977), who also found that poor self-concept goes with low academic achievement (Siann & Ugwuegbu 1980, P.76). Serpell (1976) notes that numerous cross-cultural studies have been carried out and these have highlighted the difficulty of analysing the relationships between self-concept and achievement (Serpell 1976, P.35).

One final question needs to be raised in the context of the present research and that is about the validity of the self-concept construct when applied to non-western people: does the self theory which has emerged from a western culture apply in an African context? Siann & Ugwuegbu (1980, P.74) state unequivocally that self-concept can indeed be useful in the study of students in non-western cultures and they quote the work of Wober (   ) and Bakari (1975). The former found that the factors involved in perception of self will differ from culture to culture but there is indeed a unique perception of self (op cit P.75).

Bakari showed the validity of measures of self-concept in his Nigerian sample. He found that measures of self-concept differentiated between "successful" and "failing" groups of students (ibid).

The usual technique for conducting research and gathering data relating to self-concept is by means of questionnaires and check lists or the construction of some scale of items as used for example by Minkowich et al (1982) referred to above. The weakness of this approach is that what emerges depends on what items are included. The obvious adva ge is that the materia is easily quantifiable. Other methods used include interviews, projection techniques and self report essays. The difficulty with these is the problem of how to quantify the purely qualitative data produced and this tends to offset the advantage of greater validity. There is still one major weakness of all these approaches, however, and that is that they rely solely on the verbal material and the non-verbal means by which an individual makes himself known are ignored (Gordon 1975 P.336). In the pilot study use was made of the self report essay and it was decided to use this same method for the main study.

Having defined self-concept in the terms of self-perception it was then decided to ask all the standard 7 students being studied to respond to a simple request to tell the researcher about themselves. How this was done and how it was scored is given in the next section.

9.2.2. Measuring instrument for self-concept

At the bottom of the socio-economic questionnaire page there was space left for the students to write about themselves as shown in Appendix F. The statement: "I don't know you" and the request: "Please tell me about yourself" were deemed sufficient to indicate what was required. There were seven blank lines and underneath was written "Ke a leboga" (= thank you) and the researcher's name. In Keledi school the researcher supervised this section in two of the classes and the maths teachers did the other two classes. In Matale the class teachers supervised it in their own classrooms and the researcher moved around to oversee the operation and deal with difficulties or questions. In Mafenya all the standard 7 students had been assembled in a double classroom which served as a small hall. One teacher introduced the researcher and assisted in distributing papers. In none of the classes were there any queries while the students carried out this self-concept exercise. A few students in one class used dictionaries to check the spelling of some words. Apart from that all the students were absorbed in the task.

There is no doubt that this was an excellent method to find out what the students think about themselves, judging from the candour and openness of what they wrote. However that does not take from the fact that it is difficult to quantify their paragraphs with built-in safe guards for realiability and validity. It was clearly an easy section as seen from the large number of responses. Only 11 of the 584 failed to write about themselves. It was also an enjoyable exercise as could be seen from t eir absorption and general attitude while they were doing it.

The paragraphs written by the students were scored using a simple direct scoring procedure. A score of +1 was awarded for each positive statement they made about themselves e.g. "I am beautiful". If they reinforced the statement by saying for example "My colour is black and I am proud of this" then +2 was scored for such a statement. Similarly each negative statement was scored -1 e.g. "I suffer from school fees". Again if they reinforced the statement e.g. "My uncle shout at me and I am very upset" then -2 was scored. The algebraic sum of the positive and the negative scores was then calculated as the overall self-concept score.

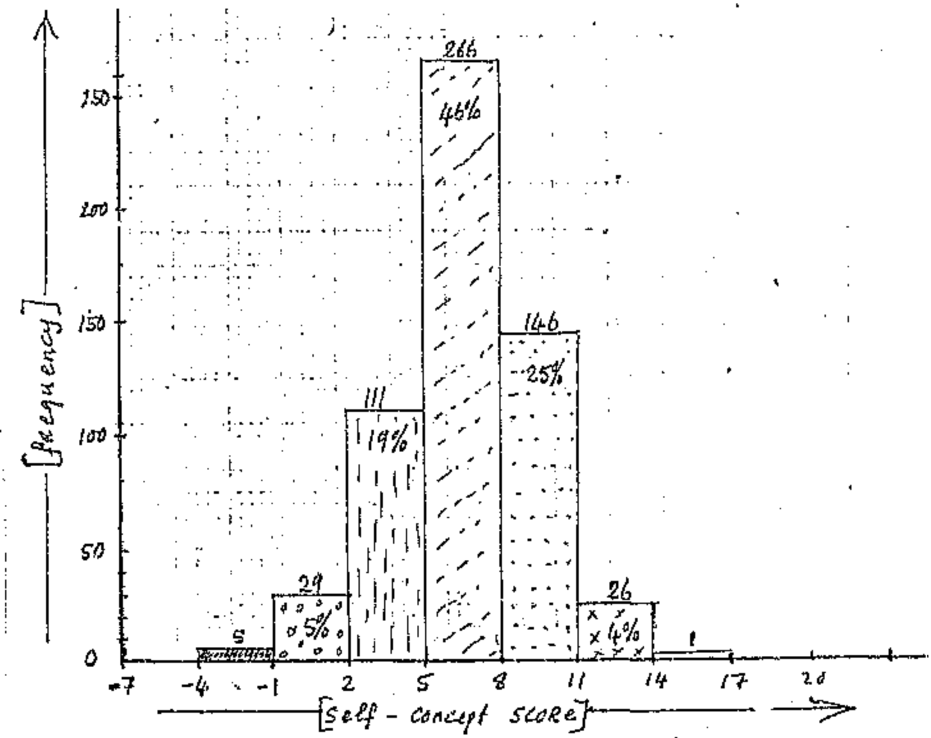
The scoring was done by the researcher and later two independent scorers separately scored a 10% sample of the paragraphs on selfconcept. Interscorer reliability figures were r=0,9676 for researcher and G. Boswell and r=0,9538 for researcher and P. Slattery. The scorers were G. Boswell and P. Slattery both of whom have spent many years working in the Bafokeng region.

The validity of the instrument rests on its simplicity and on the candour of the subjects. There was no reason for them to be untruthful and the manner in which they spoke about themselves indicated that they were being honest in their statements. There is no way to prove this because the definition of the self-concept taken for this research is the manner in which the student sees himself. Similarly apart from the inter-scorer reliability given above, other checks for reliability like repeating the exercise at a subsequent date were not deemed suitable. The reason for this decision was that doing this sort of exercise can itself be regarded as one form of self-evaluation which is understood in psychology to be the method by which a person establishes a self-concept.

> A self-image is formed on the basis of self-knowledge aquired through the act of self-evaluation (Jordaan & Jordaan 1989 P.684).

Several students talking informally after the data gathering sessions remarked on how important it was for them to get to know themselves better by spending time thinking about themselves.

Fig 9.1. Frequency distribution of self-concept scores



9.2.3. Results of the self-concept test

The scores ranged from -3 to +15 with the vast majority (56) having a positive self-concept from the scores on this instrument. Eleven wrote nothing and were scored 0 and only twelve had negative scores. The frequency distribution of the scores is given in Figure 9.1. The topics mentioned were: name, age, sex, body characteristics, behaviour, how other people saw them, parents, friends, hobbies, occupation during weekends etc. In general girls dwelt more on their appearance and the work they do at home:

> I'm a slender girl (+1) with big eyes (+1) and a beautiful nose. (+1)
> I'm fat enough (+1) and black in colour. (+1)
> At about 5 o'clock I cook food (+1) for our family.
> We are a very happy family. (+1)
> I am not well educated (-1) because my mother is still weak (-1) and at home we are suffering. (-1)
> My mother does not working. (-1) So I suffered for school fees (-1) and school ticket. When I tell my uncle for ticket every month he tell me a story for furniture. (-1)
> Now is the winter months and I have no school uniform (-1) and khaki shirt.

The boys in contrast tend to focus on their future careers and how they pass their time:

> My name is Kenneth. (+1) First of all I want to say I am an intelligent boy. (+1) I love everybody in my life. (+1)
> Every Sunday I went to church. (+1) Everybody that knows me that I have a good menus (=manners) (+1) and in my life I want to be a doctor. (+1)

School and school subjects were referred to by both boys and girls in roughly the same proportions. Most said they liked school, teachers, subjects and some were ambivalent:

> I like to study maths (+1) but I can't understand it perfectly. (-1) That's why I hate it. (-1)

Interesting as the analysis of these comments might be in themselves, the present research is concerned with how self-concept is related to mathematics and this will now be pursued.

The average scores obtained in the self-concept instument are given in Table 9.1.

Table 9.1 Average scores in self-concept

	N	TOTAL SCORE	AVERAGE
Total population	584	3606	6,2
Interview sample	60	393	6,6*
Good maths students	15	114	7,6
Weak maths students	19	113	5,9

The difference between the means for students good at maths and students weak at maths in the picture problem scores given in Table 9.1 is significant at 5% level.

It can be seen from this table that good maths students averaged higher than the population average and students weak at maths averaged lower.

Correlation between the self-concept scores and the maths exam marks were calculated using Spearman's formula. The figures are given in Table 9.2.

The results are mixed, those for Matale show a small positive correlation but Keledi and Mafenya do not. Nor is there an overall statistically significant correlation between scores on self-concept instrument and marks obtained in the maths examination.

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* The interview sample was not completely random as explained in chap. 5. Students very weak in English were excluded.

Table 9.2. <u>Spearman's correlation for self-concept/maths mark</u>

SCHOOL	N	r	SIGNIFICANCE
Keledi	297	0,076	none
Matale	157	0,192	p < 0,05
Mafenya	126	-0.161	none
TOTAL	580	-0,023	none

As already discussed in chapter 7 the maths exam marks are very low and a total of 266 (i.e. 46%) of all the students scored less than 25% in the maths examination. There is a serious doubt about the validity of maths examination marks. Application of chi squared test also yielded results which showed maths marks and and self-concept scores not significantly related at 5% level.

A second set of correlations were calculated using the performance in the five picture problems as criterion of success. Thirty four students scores were used. This group was composed of 15 students who scored A or B on the picture problems and 19 who scored D or E. Again the results showed no significant correlation r = 0,2497. From this result together with the results given in Table 9.2. two possible conclusions can be drawn. It may be (i) that the instrument used in this test was not suitable for measuring self-concept or (ii) there is no significant relationship between self-concept and performance in mathematics for the Bafokeng. It seems the latter is more likely of the two inferences in this instance.

Nevertheless good maths students do have a higher self-concept score than those who are poor at maths as judged by the performance in the five picture problems as can be seen from Table 9.1. Elsewhere the students were asked: Why do you think you are good at maths ? Invariably they say it is because of their performance in the maths tests. Relationships between variables, as has already been pointed out are complex and although other research has established positive correlations between maths and other scholastic achievement against self-concept there is no way to identify causal relationships.

Correlations cannot be used to indicate cause and effect (Gordon 1975, P.343). Not all the reasearch found positive correlations and some studies produced mixed results, as for example Stein (1971) and Fitts (1972) as quoted by Gordon (op cit P.344).

9.2.4. Deepening of self-concept investigation

In their evaluation of Israeli Primary schools, Minkowich and co-authors (1982) broke down self-concept into eleven items, each of which was tested for a possible relationship with academic performance. Two of these items were deemed appropriate for deepening the present research into how self-concept is related to mathematics performance among the Bafokeng. The two items are (i) locus of control and (ii) conception of the ideal student.

The term "locus of control" is attributed to Rotter (1966). Coleman (1966) studied how locus of control is related to performance in school. It has been suggested that if a person believes he has control over what happens to him and his locus of control can be said to be internal then such a person has a very well developed self-concept. If on the other hand an individual thinks that he has little control over what happens and his locus of control can be said to be external, then he tends to have a poorly developed self-concept (Minkowich et al 1982 P.160). The degree to which one feels he is a victim of circumstances or can influence what happens to him is neglected in the usual self-report research, claims Gordon (1975, P.345). One study quoted by Gordon was carried out by Buck and Harvey (1971) on locus of control as experienced by black Americans. They compared internal and external control of 50 black achievers with 50 black underachievers who were matched for I.Q., sex, age, and family background. They found adequate achievers scored higher on internal control. Minkowich et al found most students in their Israel study tended to attribute failure in arithmetic exercises to external factors like difficulty of the task rather than their own deficiency (<u>ibid</u> P.161). These authors say level of intelligence and socioeconomic status have a decisive influence on the direction of locus control. Low intelligence and a disadvantaged home background would normally indicate an external locus of control. However they also point out that teachers' influence might force such a student to indicate an internal locus of control in respect to school experiences (<u>ibid</u> P.164).

For the item "conception of the ideal student" Minkowich <u>et al</u> (1982) presented several questions of the form "It is better to ... than to get good marks in maths" Six of this type of question were adapted for the present research, three of them dealing with love of maths for itself and the other three dealing with human relations. The subjects were asked to mark an X in a box to indicate whether they agree or disagreed with the statement - see Appendix J.

The sample was drawn up as follows: all the std 7 students were given the 12 questions relating to locus of control and conception of the ideal student. They were then matched for

a) sex, b) age, c) father 's level of education,

d) father's occupation and finally the matched groups were analysed for performance in mathematics. This resulted in two matched groups of 30 students each, who differed in performance in maths according to the judgement of their teachers but were similar on the other four criteria as shown in Table 9.3.

Table 9.3. Composition of the two matched groups

	GROUP 1			GROUP 2		
	Boys	Girls	Total	Boys	Girls	Total
Number in sample	17	13	30	17	13	30
Average age (years)	15,9	15,2	15,6	16,1	15,4	15,8
Highest std reached by father	8,3	8,0	8,2	7,7	8,8	8,2

The replies of these two matched groups to the questions are given in Table 9.4.

The results show the two groups are remarkably similar and there no significant differences to locus of control between those who are good at maths and those who are weak at maths. In their answers to all the questions the biggest number of students in each group see themselves as the authors of their own fate - test marks etc. are seen to depend on their own efforts.

This indicates that both groups do have well developed self-concepts. It also supports the findings of section 9.2.3. that there is no distinction between those good at maths and those not good at maths on self-concept scores.

Table 9.4. Replies to "locus of control" questions

STATEMENT	GROUP 1 Good maths students	GROUP 2 weak maths students
1. When you succeed in maths tests it is because:		
(a) you studied hard	25	27
(b) the test was easy	5	3
2. When you remember something in maths:		
(a) you went over it many times	17	16
(b) it was easy to learn	13	14
3. When your parents reward you for succeeding in your studies it is because:		
(a) they love you very much	12	12
(b) you work so hard	18	18
4. When your teacher says your homework is unsatisfactory it is because:		
(a) the homework is difficult	11	9
(b) you did not try hard enough	19	21
5. When you find it hard to solve maths problems:		
(a) you did not study enough	22	22
(b) the teacher gave difficult problems	8	8
6. If your teacher thinks you are stupid in maths:		
(a) you don't study very hard	18	16
(b) you don't have any brains for maths	12	14

Question 7 to 12 inclusive investigated the conceptions held by the two groups about the ideal student. Three of these (Q.7, Q.8, Q.10) examined the relative importance of good maths test marks compared to independent thinking and love of mathematics for itself. The results are given in Table 9.5.

Table 9.5. Importance of good marks compared to love of maths

STATEMENT	AGREE		DISAGREE	
	Group 1	Group 2	Group 1	Group 2
7. It is better in maths to do exactly what the teacher says than to think about solving a problem in your own way	26	20	4	10
8. It is better to love maths for itself than to get good marks	16	15	14	15
10. It is better to get good marks in a test than to love doing maths problems	18	10	12	20

The differences between the two groups are not statistically significant for Q7 and Q8 but for Q10 $p<0.01$. According to the replies to question 7 few of the students are confident enough to try solving problems on their own and prefer to stick closely to what the teacher tells them to do. It is interesting to note that the group of students weak at maths are more venturesome than the good maths ones and more than twice as many of the ones weak at maths would be prepared to chance their own solution as compared to the ones good at maths. Question 10 clearly differentiates between the two groups ($p<0.01$). Most of the good maths students think it is better to get good marks in tests while by comparison most of the students weak at maths think it is better to love doing maths problems than to get good marks. It might be a partial explanation to relate this to their relative experience of actually getting good marks in maths tests in the first place - the good students have experienced success and the students weak at maths may never have had this experience. The remaining three questions examine the ambition to succeed in maths as opposed to basic human virtues which are honesty, consideration for others and helping a friend in need. The replies to Q.9, Q.11, Q,12 are summarised in Table 9.6.

Table 9.6. Importance of good test marks compared to human virtue

Q.	STATEMENT	AGREE		DISAGREE	
		Group 1	Group 2	Group 1	Group 2
9.	It is better to be hard working in school than to be an honest person	18	25	12	5
11.	It is better to be considerate to your freinds than to succeed	9	7	21	23
12.	It is better to spend time doing your own homework than helping your friend who is weak in maths	21	16	9	14

The differences between the two groups are not statistically different for Q11 and Q12 but for Q9 $p<0.05$.

Chi squared tests carried out on the data from Table

9.5. and Table 9.6. show the differences between the two groups are not statistically significant apart from Q9 and 0.

Hardwork, success in school and doing one's own homework are seen to be more important than honesty, consideration and helping a weaker friend. In Q.9 and Q.11 the majorities are fairly large. Only when it comes to Q.12 - helping one's friend who is weak at maths - do the replies indicate a social awareness at least among the students poor at maths. Almost half of the weak maths students but less than one third of the good maths students think it is more important to help others. However in contrast to this only 17% of the weak maths students compared to 40% of the good maths students think honesty is more important than schoolwork. This set of replies must be frightening and lead us to question the value system of the schools which the students seem to have internalised.

To summarise this section the results show that a general pattern where the good maths students agree that it is better to do exactly what the teacher says, to get good marks in maths tests and to spend time doing one's own homework than attempting to think for themselves, learn to love maths for itself or spending time helping a weaker friend. More of the poor maths students compared with good maths students think it is better to be hardworking in school than to be honest. Finally the good maths students are different from the weak maths students in that they are more hardworking, more dedicated to doing homework, more ambitious, more inclined to follow the teacher's instructions than to take the risk of thinking for themselves. The good maths students as a group are more conservative and ambitious. The weak maths students see the ideal student as more friendly and outgoing.

9.2.5. Summary and conclusion

In the analysis of the self-concept variable as presented in this section no significant correlations were found between the group of students who were good at maths and the group of students who were not good at maths, whichever criterion of success in maths was used. Small differences in average self-concept scores were recorded but they are not sufficient to lead to rejection of the null hypothesis that there is no relation for the standard 7 students in the Bafokeng region between self-concept and maths performance. In attempting to understand these findings the manner in which mathematics is viewed by the Tswana people must be borne in mind. Mathematics is a western way f looking at reality. It is useful for the Tswana because it enables them to get certain kinds of jobs like pay clerks at the mines which are regarded as a big improvement on digging underground. There are several reasons for this, not-least of which are: (i) better pay, (ii) surface jobs enjoy a high status, (iii) risk of accident or injury is much greater undergound, (iv) more opportunities for social exchange in an office than working at the mine face.

Success and failure in mathematics is not seen to be a reflection on a person's scholastic ability. The researcher has seen the way good svmbols in different subjects are regarded by teachers and students alike. An "A" scored in Home Economics or in Bible Studies for instance is looked upon as being not much different from an "A" scored in mathematics Higher Grade and all are greeted with the same level of appreciation.

Hence it can be seen that students who fail in mathematics do not allow this failure to damage their self-concept and they will continue to have a positive image of themselves. Nonetheless the findings need to be followed up and further research in the area of self-concept and mathematics is necessary.

9.3. Attitudes to mathematics

9.3.1 Background

There is considerable looseness about the use of the term "attitude" in the literature. Allport (1961) argues that it is not always possible to distinguish between a personality trait and an attitude. That which characterises an attitude is (a) it is always connected to a specific idea of reference or object, it is more specific than general and (b) it can usually be divided into favourable (positive) or unfavourable (negative) categories thus leading to approach or avoidance behaviour (Jordaan & Jordaan 1975, P.845). ... er and Pauli (1971 P.92) and many others define attitudes in terms of a body of feeling directed towards a particular set of objects. Rokeach (1968) has the same idea when saying an attitude is:

> ... a relatively enduring organisation of beliefs around an object or situation predisposing one to respond in some preferential manner (Rokeach 1968 P.450).

There are three parts to this definition. First it defines an attitude as some kind of collection of beliefs which, secondly are directed towards something, and thirdly they lead to a response. In the present research attitudes are taken to be feelings towards mathematics which predispose the student to respond either positively or negatively to the demands made on them in this subject.

There is general agreement that the attitudes are determined by social factors and the first and most influential of these is the home group (Murphree <u>et al</u>, 1975, p.16). McClelland discusses the importance of the parent-child interaction for boys with high and low achievement scores and he claims that the child's attitudes are related to those of the parents (McClelland

1961, p.351).

In a study of pupil failure in primary schools of the Ciskei in South Africa Nyikana identifies parental attitudes as one of the most important external influences operating against the child's success at school. These attitudes are shaped by the parents' own experiences and transmitted to the children (Nyikana 1982, p.92). The pilot study described the background to the attitudes to the mathematics variable which is taken as a home variable for the purposes of the present research. It was pointed out in section 7.1. above that the influences other than the home may well affect the student's attitudes to mathematics.

In the present context what is being investigated is whether or not there is a significant relation between attitudes and the success in mathematics and what is the nature of the relation. Two ways of defining success in mathematics were given in chapter 2 viz. (i) good mark in the standard 7 mathematics examination and (ii) performance in the five picture problems discussed in chapter 6. Both of these are tested against attitude scores measured using the questionnaire in the next section. This questionnaire is based on fixed response items as commonly used in the literature for attitude studies. The items were based largely on Husen's work (1967) and adapted for use with the standard 7 students in the Bafokeng region by this researcher.

9.3.2. Instrument for measuring attitudes to mathematics

9.3.2.1. Description of instrument

Most often the method used to measure attitudes is to elicit acts of judgement on the part of the subject by inviting them to respond in favour of or against a given statement.

> As inferred dispositions, attitudes are customarily measured by eliciting acts of judgement: agreement or disagreement, with standard statements of opinion (Smith 1968, p.461).

Peaker (1975) used a two point scale (agree/disagree) to measure attitudes to school (Peaker 1975, P.199). While this has the advantage of simplicity it does not allow for those students who are unsure or who simply don't feel one way or another about a particular statement. For that reason some researchers favour instead a three point scale which allows for a neutral "I don't know" or "Not sure" response. In this way the subject can skip an item without feeling guilty for not answering all the questions. Posier (1978) studied attitudes to school among sixteen year olds and he allowed for one of three responses (ibid P.156). Kiely (1983) used a five point Likert scale to measure attitudes of High School students in Phokeng towards home, school, friends, authority and self (P.109). After preliminary testing with a five point scale which allowed the subjects to choose: a)strongly agree; b)agree; c)undecided; d)disagree; e)strongly disagree; it was decided that for this research a three point scale a)agree; b)don't know; c)disagree; would be more useful and this form was tested in the pilot study and proved satisfactory. Thirty-five items were presented in the form of statements about mathematics, these statements were for the most part written in the first person. The students were asked to indicate whether they agreed, disagreed or were not sure by making a mark in the appropriate box. A copy of questionnaire is given in Appendix C. Item 2 and item 34 both of which concerned feelings about mathematics homework were used to measure consistency of students' responses.

9.3.2.2. Scoring of attitudes questionnaire

The researcher and two other scorers working independently, marked what each one considered a positive as opposed to a negative attitude, for each statement. It was decided that items number 10 and 11 and items 13 and 14 were superfluous because they were included for most students in their standard 6 experience which was the substance of items number 12 and 15. For this reason 10, 11, 13, and 14 were not scored. Item 34 was a repeat of item number 2 and it also was not scored. No agreement could be reached about what constituted a positive attitude for item number 22 and it was omitted. The scoring is given in Table 9.7. Two punch cards were then prepared, one with windows to allow only positive responses to be counted and the other with windows to allow only negative responses to be counted. The maximum (positive) score was +29 and the minimum (negative) score was -29. The positive and negative scores were then combined algebraically to give an overall attitude to mathematics score for each student.

All the statements were apparently understood by the students and there were no ambiguities that required ex- lpanation during the administration of the test. The procedure followed was the same as already described above for self-concept.

Table 9.7 Scoring of items in the attitudes questionnaire

ITEM	RESPONSE	ATTITUDE	SCORE
1,4,6,7,8,9,18,23,25,27, 28,32 (12 items)	Yes; agree	Negative	-1
2,3,5,12,15,16,17,19,20, 21,24,26,29,30,31,33,35, (17 items)	No; disagree	Negative	-1
1,4,6,7, etc.	No; disagree	Positive	+1
2,3,5,12, etc.	Yes; agree	Positive	+1

9.3.2.3. Validity and reliability

The validity of the instrument used to measure attitudes to mathematics is based on the three steps used to ensure that the instrument was in fact measuring what it set out to measure. These steps were:-

1) A study of the relavent literature and in particular the use of Husèn's (1967) questionnaire in the international study of achievement in mathematics.

2) Application of triangulation techniques (Cohen and Manion 1980, P.211) to validiate the over-all score by obtaining information about attitudes to mathematics from more than one source. Two sources were used for this purpose namely the questionnaire scores and the replies of the students to the open-ended questions shown in Appendix D. The distribution of scores given in Fig. 9.2. shows a roughly normal distribution. The qualitative statements made by the students were classified as follows:-

Strongly positive (+2); positive (+1); neutral (0); negative (-1); strongly negative (-2). The total of positive scores and the total of negative scores was then counted. This score was then correlated with the scores obtained in the questionnaire and the results are given in Table 9.8.

3) The scoring of each question by using three scorers marking independently. The markers were the researcher, together with P. Slattery and J.P. Murphy. All three markers have been involved in mathematics teaching in the Phokeng area for several years. Inter-marker agreement was 100%.

Reliability of the responses was calculated in two ways viz by the split-halves technique and by a check for internal consistency done by repeating a question.

Table 9.8. Correlation between attitudes scores

SCHOOL	CLASS	CORRELATION BOYS	CORRELATION GIRLS	SIGNIFICANCE
Keledi	7A	0,9126	0,8636	
	7B	0,8105	0,8501	
	7C	0,7866	0,8764	
	7D	0,8434	0,9283	$p < 0,01$
Matale	7A	0,7642	0,6582	
	7B	0,6964	0,8527	
	7C	0,9275	0,8537	
	7D	0,6614	0,8244	$p < 0,01$
Mafenya	7A	0,7340	0,8756	
	7B	0,8221	0,8052	
	7C	0,8304	0,9536	$p < 0,01$

1) A sample of 20 attitude questionaires was drawn randomly from the population. These were now scored by using the odd numbered items only and then scored using the even numbered items only. The scores obtained in each half were then correlated using Pearson's formula. The Figures for each half are given in Table 9.9.

Table 9.9. <u>Split halves scores for attitudes responses</u>

	N	TOTAL	AVERAGE	
				r = 0,8236
Odd numbered items	20	1138,3	56,9	df = 19
Even numbered items	20	1098,2	54,9	p < 0,01

The scores had been converted to percentages for use with a computer programme.

2) An internal consistency control was built into the questionnaire because the level of English language comprehension of the subjects was foreseen to be a limiting factor on the reliability of the responses. In Q.2 the students were asked about liking maths homework using a positive statement and this was repeated in a negative statement in Q.34. The number of subjects whose responses to these two items were self-contradictory was counted and percentages calculated as shown in Table 9.10.

The figures given in Table 9.10. show as overall 20% lack of understanding among the 584. This is an extremely high figure and indicates the poor level of comprehension among the std 7 students. It also points to the need for great caution when interpreting the final scores.

Table 9.10. Consistency of responses for attitudes questionnaire

SCHOOL	CLASS	SELF CONTRADICTORY	TOTAL RESPONSES	PERCENTAGE CONSISTENCY
Keledi	7A	15	78	81%
	7B	15	73	79%
	7C	17	77	78%
	7D	15	74	80%
Matale	7A	6	39	85%
	7B	10	50	80%
	7C	6	28	79%
	7D	4	40	90%
Mafenya	7A	10	44	77%
	7B	9	43	79%
	7C	9	38	77%
TOTAL		116	584	80%

It will be remembered the bottom third was excluded from the interview sample because of poor English comprehension in chapter 5.

9.3.3. Findings of attitudes questionnaire

Altogether 584 std. 7 students completed the questionnaire on attitudes to mathematics. All the students completed all the questions though in a few instances students marked more than one response. The scores ranged from -18 to +29 with the overall average +10,4. The average scores for each school are given in Table 9.11 and the frequency distribution in figure 9.2.

Table 9.11. Average scores on attitudes to maths questionnaire

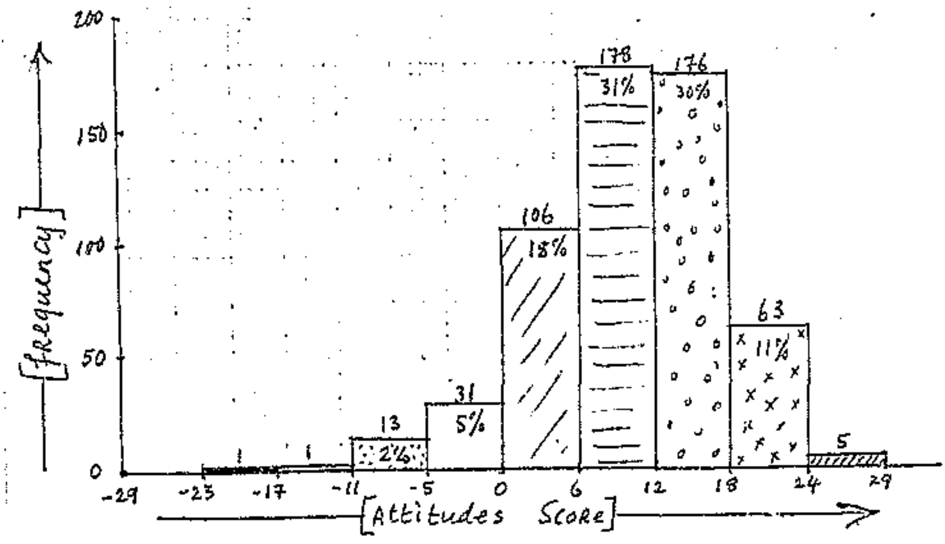
SCHOOL	N	AVERAGE	STANDARD DEVIATION
Keledi	301	10,1	6,6
Matale	157	11,7	6,1
Mafenya	126	9,4	8,7
TOTAL	584	10,4	7,0

Matale school has the highest average. This may be related to the special features of that school discussed in Chapter 8,4 namely of the three schools Matale is the longest established, has the most experienced teachers, and the students generally are from higher socioeconomic status families.
Mafenya has the lowest average. This may be related to the conflict situation that seems to exist between the maths teacher and the departmental head in that school which was referred to in Chapter 8. The std. 7 maths teacher claims that the departmental head often interferes with her work and presumably the disagreement would be noted by the students and even subconsciously

affect their attitudes to maths.

Over half of the students have scores between +7 and +18. Most of the students scored positively and there were only 46 negative scores.

Figure 9.2. Frequency distribution of scores from attitudes to maths questionnaire



Spearman's correlation coefficient was calculated for scores obtained in the attitudes questionnaire with (i) maths mark and (ii) average score in the five picture problems. The figures for each of these are given in

Tables 9.12. and 9.13. respectively.

There is a strong positive correlation ($p < 0,01$) between scores on attitudes questionnaire and maths mark obtained in the June 1987 examination.

Table 9.12. Correlation coefficient between attitudes and maths mark

SCHOOL	N	r	SIGNIFICANCE
Keledi	301	0,3568	$p < 0,01$
Matale	157	0,4022	$p < 0,01$
Mafenya	126	0,4741	$p < 0,01$
TOTAL POPULATION	584	0,3383	$p < 0,01$

Table 9.13. Correlation coefficient between attitudes and picture problems

SCHOOL	N	r	SIGNIFICANCE
Keledi	20	0,4964	$p < 0,05$
Matale	6	0,3618	none
Mafenya	8	-0,4038	none
TOTAL SAMPLE	34	0,4038	none

Apart from Keledi there is no statistically significant correlation between attitudes scores and picture problem scores. This could be due to the small N for the picture problems. Another possibility is that there is a real difference between the variables being measured by the maths mark and by the picture problem score.

9.3.4. Comparison between good and not good at maths on attitudes

The students who are good in maths using the criterion of maths mark have higher scores on the attitudes questionaire than those who are not good in maths. In Table 9.14. the attitudes scores for students who obtained 40% or more in the maths exam are compared with the attitudes scores for students who obtained 20% to 29% in the maths exam.

Table 9.14. Comparison between attitudes of good at maths and not good at maths

SCORE	NUMBER		PERCENTAGE	
	GOOD	NOT GOOD	GOOD	NOT GOOD
+25 - +29	2	0	1,6%	0,0%
+19 - +24	24	14	19,8%	8,0%
+13 - +18	45	50	37,2%	28,7%
+ 7 - +12	39	50	32,2%	28,7%
+ 1 - + 6	10	38	8,3%	21,8%
- 5 - 0	1	17	0,8%	9,8%
-11 - -16	0	4	0,0%	2,3%
-17 - -12	0	1	0,0%	0,6%
TOTAL	121	174	99,9%	99,9%

Chi squared test carried out on the data of Table 9.14

shows the attitudes of those good at maths to be significantly different ($p < 0,01$) from the attitudes of those not good at maths.

It can be seen from Table 9.14 that 26 out of the 121 students who are good at maths scored +19 or above in the attitudes test this is 21%, and only one had a negative score.

By comparison only 14 of those who are not good at maths scored +19 or above in the attitudes test which is only 8% whereas 22 of these students had negative scores which is 13% of the 174.

Altogether there were 68 students who had attitudes scores of +19 or above and there were 46 who had negative attitudes scores. The maths marks for these two groups were averaged and are given in Table 9.15.

Table 9.15. Maths marks of high attitudes scoring students and low attitudes scoring students

SCHOOL	NUMBER OF HIGH POS. SCORES	AVERAGE MATHS MARK	NUMBER OF LOW NEG. SCORES	AVERAGE MATHS MARK
Keledi	33	44%	24	25%
Matale	19	34%	4	18%
Mafenya	16	30%	18	13%
TOTAL	68	38%	46	20%

Again the same relationship is revealed viz. that the students who scored high on the attitudes test have maths average almost double that of students who have negative attitudes towards maths.

Finally the attitudes scores of the two groups of those good at maths and those not good at maths using the criteria of performance in the five picture problems were calculated and presented in Table 9.16.

Table 9.16. Average attitudes scores of interview Sample

GROUP	N	ATTITUDES TOTAL SCORE	ATTITUDES AVERAGE
Students good at maths	15	236	15,7
Students not good at maths	19	240	12,6
Interview sample	60	842	14,0

The group of students who obtained A or B in the five picture problems scored 1,7 points above the average for the interview sample but the students who obtained D or E in the five picture problems scored 1,4 points below the interview sample.

Just as with the variables discussed in Chapter 7 and the self-concept discussed earlier in the present Chapter 9 it is not possible to determine with certainty the direction of the relationship between attitudes and success in maths whichever criterion is used. It seems likely none the less that for attitudes more than for any of the other variables the likelihood is for a genuine non-chance relationship. Those students who have a negative attitude to maths will tend to be less well activated to study maths and to spend time doing maths exercises, and hence will tend to perform badly in maths examinations. Similarly those students who have positive attitudes towards maths will experience more satisfaction in working at maths exercises and will spend more time at maths and consequently will tend to do better in the maths examinations. It may be however that students develop a positive or a negative attitude towards maths in the first place because of their experience of passing or failing maths tests.

9.4. Cognitive variables

9.4.1. Background

In the original research proposal it was set out that this research would focus on how the standard 7 students in the Bafokeng region learn mathematics. In the literature, cognitive style appeared as a means towards this end. Cognitive style refers to the unique way an individual searches for meaning and how he processes information. It includes the ways in which sensory stimuli are perceived and interpreted, the strategies that an individual uses in forming concepts, solving problems and learning a given body of content material. All this means that cognitive style acknowledges that individual differences in cognition do exist and they can be studied and researched. Cognition in this context is taken in the usual sense of mental processes which include perception, thought, memory, imagery and problem solving (Ewan et al 1984, P.59). As the research progressed it became clear that an undertaking which tried to cover all aspects of cognition was impossible and the decision was taken to limit this research to the first aspect of cognition namely perception. That focus is continued in the present section and other aspects of cognition will only be referred to in passing.

Ewan (1984) describes three main branches in the field of cognitive style which are:

(i) Field Dependence and Field Independence

(ii) Reflexivity and Impulsivity

(iii) Kolb's analysis of basic learning styles.

Only the first of these was used in the present research although in some instances one or other of Kolb's four basic learning styles or aspects from the impulsive/reflective research was noticed. It was especially during the interviews when the students worked through the five picture problems described in chapter 6 and later in the experiments on how the students organise data in a problem situation described in chapter 7 that the cognitive differences were most in evidence.

In keeping with the spirit of the present research this focus here is more on mathematics teaching and learning than on educational or psychological theories. Some of the most important material in this field results from a 12 year study into the differences between students good at mathematics and others who were not good at mathematics. This was the work of Kruteskii (1976) who published his findings in the book entitled: The Psychology of Mathematical abilities in School children. The aim of this work had been:

> to clarify the features that characterize the mental activity of mathematically gifted pupils as they solve various mathematical problems (P.76).

During the investigation Kruteskii found that some of the important abilities that discriminate between good and problem solvers were:

a) they could distinguish relevant from irrelevant information

b) they could quickly and accurately see the mathematical structure of a problem

c) they could generalise across a wide range of similar problems

d) they could remember a problem's formal structure for a long time.

Referring back to chapter 6 the students who performed poorly in the five picture problems reported in that chapter seemed to have difficulty in remembering, even for a short time what it was they were asked to do. Also in the perception experiments reported in chapter 7 the same behaviour was noted. On a number of occasions the interview went like this:

I: What are you trying to do ?

S: No reply ... silence ...

I: What did I ask you to do with these objects ?

S: I don't remember ... I have forgotten ...

In commenting on Kruteskii's work, Lester (1983) notes that one of the important aspects of it was the shift towards characterizing problem solvers according to the types of mental processes they use (Lesh & Landau 1983, P.235). Bishop (1983) discusses individual differences in the same vein and says about Kruteskii's findings that the more able group could grasp the problem as a whole, they could integrate the seperate elements into a significant ordered structure. The less able students on the other hand were tied to the details of the problem, seeing only disconnected facts and treating them all with equal significance.

In the perception tests described in chapter 7 it emerged that the students weak in mathematics were unable to grasp the fundemental issue in the task using squares, triangles and circles which was that they were asked to make four bundles. They were occupied only with the three classes of shape or of colour. They were unable to distinguish the "threeness of colour" from the "fourness of bundles". They could only make three bundles because they could only focus on the property of colour and the number perceived related to this property. In the picture problems it was also found that the students poor at maths were unable to distinguish relevant from irrelevant information. For example, picture problem number 2 which showed a tree with six apples and a boy who says he has eight similar trees - how many apples altogether ? Some of the students who couldn't handle this question got lost in describing the apples - their size, quality etc nd rgot they were asked how many apples there were. The same thing was reported in picture problem number 1, where they were asked to calculate the distance from Rustenburg to Sun City. The poor performers concentrated on the boy sitting under the post - he was tired - he was waiting for transport etc. Kruteskii's findings led him to suggest there are different types of problem solving behaviour according to preferred modes of mental processing. The two main types are:

(i) Analytic type: The analytic type describes those students who had a very well developed verbal-logical component and who operated easily with abstract schemes. They had no need for visual supports in problem solving even when the mathematical relations given in the problem suggest visual concepts (Kruteskii 1976, P.317).

(ii) Geometric type: The geometric type refers to those students who showed a strong well developed visual-pictorial component in their thinking and for them figurativeness often replaces logic (<u>ibid</u> P.321).

From the results of the five picture , oblems and the perception tests of the present research it appears that among the Bafokeng both of these types also exist. However many of the Bafokeng standard 7 students belong to a third type of those whose preferred mode is geometric but due to the lack of visual stimulation or adequate use of concrete material in the classroom they are unable to pursue their preferred mode of thinking and are forced to operate in the verbal-logical mode which is not suitable for them.

9.4.2. <u>Embedded figures test</u>

At this stage of the research a serious decision had to be faced.

Cognitive abilities are ultimately the ones which are crucial in doing maths but how do these abilities develop and what are the formative influences operating in a student's life which one to success in mathematics tests and another to failure and low marks. Piaget's developmental stages were discussed in chapter 3 section 3.2.3. Skemp's model of how a person approaches and deals with a problem was outlined in section 3.2.4. Witkin's work on cognitive ..yle based on perception was described in section 3.2.5. In one sense all these shed light on how the Tswana students have in problem solving situations and in another se , there is something lacking in all of them.' Chapter 7 section 7.4. took up the challenge of field workers like Bishop, Gay & Cole, Lester and so on who focussed on the child learning mathematics rather than the elaboration of theories. In the final analysis it is not possible to separate the two. Description and theory building are linked and the one is meaningless without the other. But the dilemma now facing this research was what to do about cognitive variables - to treat them as just one group of variables among so many others was obviously inadequate, but to delve into the matter deeply was impossible taking into account the constraints of time and finance. Hence a compromise was reached. A well tested instrument for measuring scores on an embedded figures test was available. This test is the Group Embedded Figures Test (GEFT) developed by Witkin et al (1971). The GEFT claim the designers, gives a measure of cognitive style - field dependent or field independent - by means of a perception test. An outline of Witkin's EFT, on which the GEFT was based is given in chapter 3 section 3.2.5. It was pointed out in this section that Wober (1966 & 1967) among others criticised the use of EFT as a measure of field dependence/independence among African subjects. But the criticisism is directed more at the personality traits which are supposed to be related to EFT scores than about mathematics performance. What is of interest here is the ability ascribed to field independence persons:

> to recognise the elements in a perceptual situation and coordinate them into a new and meaningful whole (Jordaan et al 1975, P.172).

It was noticed by the researcher in the perception tests described in chapter 7 section 7.4. that some subjects possessed the ability to analyse the task, to break down the given data into units of perception and then to recombine them into new arrangements which eventually produced an acceptable answer. This ability was possessed by those students who were able to deal with the three groups of counters (triangles, squares and circles) which they were asked to make into 4 bundles. Good maths students could do so readily but students poor at maths were unable to succeed in this task.

Only when sweets, grapes and stones were introduced and when four people were present to whom these items could be physically distributed were the students poor at mathematics able to deal with the problem. This group of students poor in mathematics seem best described as field dependent who according to the literature are:

> easily bogged down in details because of (his) inability to coordinate these details and perceive a new totality (op cit).

The students poor at mathematics focussed on the shape or colour and discovered "threeness" was for them the outstanding feature. The problem required them to make four groups and they were not able to clear their minds of "threeness" in order to explore the possibility of "fourness". They were given twelve red triangles, twelve red circles and twelve red squares. They immediately grouped the objects which were in disarray when they started, into three groups by shape with twelve counters in each group. The task required them to distribute the counters among four people. They were unable to recombine the three groups into thirty-six counters nor alternatively to consider each group of twelve separately and extract four groups of three triangles, four groups of three squares and four groups of three circles. In the field-dependent|independent theory this ability is called the disembedding ability and it has been measured using the EFT and GEFT. For these reasons it was decided at a late stage in the research to administer the group embedded-figures test to a sample of standard 7 students in order to measure the relationship between it and mathematics success using the criterion of mathematics examination marks.

Ideally it would have been best to have been measured embedded figures ability using the same subjects as took the battery of tests in 1987 but this was impossible because most of those students had left the middle school at the end of 1987 on completion of standard 7. It was decided to use all the standard 7 students at one of the three middle schools drawn at random and Matale was drawn. The enrolment in the four standard 7 classes there were just over 200 students. Copies of the GEFT were prepared for that number and arrangements made with the principal and teachers who were, as on all previous occasions, most helpful and cooperative. In point of fact the explanations and administration of the test took much longer than anticipated (up to one and a half hours for each class) and only three classes were done. However since this constituted a group of 150 students it was seemed sufficient for the purposes of this research.

Scoring was done as directed in the manual by using a separate score sheet which was provided with the kit. The number of correct items to be taken as the score. Maximum was 18 and minimum 0.

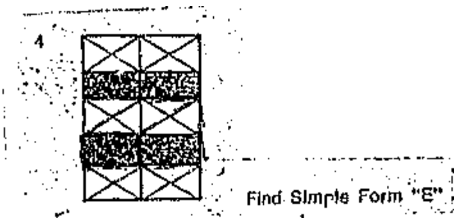
9.4.3. The GEFT instrument

The Group Embedded Figures Test (GEFT) was designed by Witkin and his associates (1971) as an instrument which could be used with large groups to gather data on the ability measured by the EFT. Many of the items were borrowed from the EFT and a number of trials conducted until the authors had established that GEFT scores were consistent with the EFT scores. The test is in the form of a booklet with four sections. There is a simple introduction and explanation which guides the subjects on the techniques to be used in doing the test; then there are 7 practice items and lastly two sections each containing nine complex figures. The subject is provided with eight simple forms labelled A to H which vary from a simple T shape to a cuboidal box. In sections two and three which are the only ones to be scored the subject is given nine complex figures and is told for each one which simple form is hidden in it. The subject must then find the simple form and outline it with a pencil. The GEFT instrument is given in Appendix K.

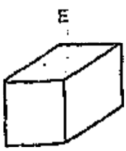
Item no. 4 in the second section has the complex figure shown in Fig 9.3.

Figure 9.3. Item no. 4 of the GEFT

Here is a complex figure 4 :



On another page the simple form E is shown thus :



Shading is used in the GEFT to replace the colour used in the original EFT. The manual stipulates that this is a speed test but does not specify what time should be allowed. It states the time allowance found to be suitable for American males at College level was five minutes for each section but that ten minutes was found to be more realistic time for 12 year olds and it suggests that the time should be adjusted to suit the group. In preliminary trials with standard 8 pupils at Bafoken High School it was found that it required 10 minutes for these students to do one section of nine items. This amount of time enabled four (three boys and one girl) students to complete all nine items. It was decided that fifteen minutes would be suitable for the standard 7 students for each section. While this might seem too generous it must be remembered that the present research was not a cross cultural one and what was here of interest was the relative performance of the students to each other not how they performed relative to American College students or any other outside group.

The validity of the GEFT is discussed by the designers of the test against three criteria: (i) Scores on EFT (ii) Scores on RFT and (iii) Degree of articulation of the body concept. There are very high correlations for the score on the Rod and Frame Test (Witkin et al 1971, p.29).

The test manual suggests a reliability coefficient can be calculated from the scores obtained by the subjects in the second and third sections of the GEFT. Each of these has nine items and subjects are allowed the same amount of time in which to complete each section.

Scores of the 32 matched pairs of subjects were correlated using Pearson's product moment correlation coefficient. A high positive correlation $(r = 0{,}7366)$ was found and this is significant at the 0,1% level.

9.4.4 Findings of the GEFT test

A total of 153 standard 7 students were tested. The frequency distribution is given for the results in Figure 9.4. The scores range from 0 to 18.

Chapter 7 has established that performance of students in the picture problems is significantly related to the S.E.S. Hence it was decided that the analysis must follow this finding. A crude measure of S.E.S. can be based on education and occupation of parents and matching on these two measures was done. Futhermore it would be shown in section 9.5 of the present chapter that age and sex of students are also significantly related to performance and these were also controlled.

Hence two sets of subjects were matched according to (i) sex (ii) age (iii) father's education and (iv) father's occupation, all of which were similar in each of the matched pairs. Then the marks obtained by the students in maths tests were compared and two groups of 32 remained. These two groups were the same in all four matching criteria and differed in their math's test scores. These two groups were then compared for performance on the GEFT.

Figure 9.4. Frequency distribution of GEFT scores

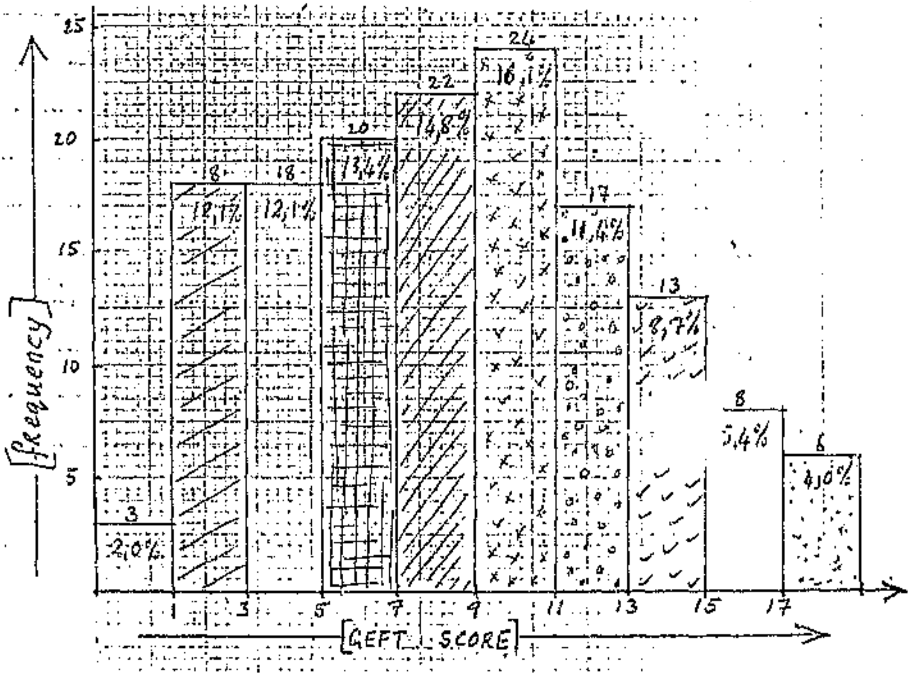


Table 9.17. Average scores of good and not good maths Students on GEFT

GROUP	N	TOTAL GEFT SCORE	AVERAGE
Students good at maths	32	343	10,7
Students poor at maths	32	317	9,9

The average scores of the students good at maths (scored 40% or over in maths tests administered by class teacher) were compared to the average scores of the students who were poor at maths (scored 30% or lower in maths tests). These averages are given in Table 9.17. There is no significant correlation between maths test marks and GEFT scores. Differences between boys' scores and girls' scores are dealt with in section 9.5. Three facts have been established for the standard 7 students tested: (a) some std 7 students get good marks in mathematics tests (b) some std 7 students score high on GEFT (c) there is no correlation between the two sets of scores. It was established in section 9.2. of the present chapter that the kind of student who gets high marks in maths tests is characterized by being conservative and not prepared to take risks in doing maths exercises, they follow exactly what the teacher says. On the other hand the students who do not perform well are more ready to experiment for themselves.

Another point which emerges from the literature is that a mismatch between teaching style of teacher and student leads to learning problems (Shipman & Shipman 1985, p.243). For example a field dependant student finds it difficult to differentiate and then e-integrate the elements in the perceptual field and if such a student is taught by a teacher who relies solely on analysis and synthesis methods which are suitable for field independant students then such a student will find it very difficult if not impossible to learn material in such a manner. During the lessons observed in this research and described in chapter 8 it was discovered that all except one teacher rigidly adhered to the text book and could not be said to have any unique teaching style. All used an adapted form of the lecture method. There were no teaching aids used. There were no charts, pictures or diagrams of any sort displayed in the classrooms. No original examples either from the teacher's experience or that of the students were reffered to. There was no group work, no hypothesis testing and no discussion. It was not possible to identify features that might be described as either field dependent or field independent teaching.

9.4.5. Summary

The background to field dependent and field independent cognitive styles was given in chapter 3. It seemed attractive for this research because Wober, Okonji and others had investigated how child rearing practices in certain African regions contributed to field dependence. This seemed very important in the light of findings elsewhere which linked field independence with analytic style of problem solving and hence with success in mathematics. It was expected that high scores on embedded figures test (which indicated a field independent style) would be stronqly correlated to high scores on maths tests. The findings reported in this section show there is no such correlation for standard 7 students in the Bafokeng region. One possible answer to why this is so may be found in the mismatch between teaching styles in the middle school maths classes and the learning styles of the students.

9.5. Other variables

9.5.1. Introduction

In a sense this is a tidying up section. The investigations carried out during the present research into mathematics among the Bafokeng produced considerably more data than the research could deal with effectively. Some of this material does give a pointer for possible directions for further research and it is presented here in a factual manner without the analysis which has been gone into with the variables discussed in chapter 7, chapter 8 and the previous sections of this chapter.

A great number of variables have been studied in relation to school achievement as reviewed for example by Alexander & Simmons (1975) anu Schiefelbein & Simmons (1978). Sex and age of students were examined in the I.E.A. research for correlation with achievement in 23 countries. Larter and Gersham (1979) in Canada, studied age and sex characteristics of students who had been identified as having learning problems. Other research e.g. Levy (1971) looked at the effect of grade repetition and homework patterns to try and find out how these might be related to performance in school. Auerbach (1978) included age and progress in school among the variables which made up the Pupil Profile Index (P.P.I.) in his study of the problems associated with early leaving in South African non-white schools.

Data concerning the following variables will be given in this section:

(i) Age

(ii) Sex

(iii) Repetition of standards

(iv) Homework patterns

(v) English language ability

As with the variables treated already, two criteria for success in mathematics will be used separately, namely maths test marks in the June 1987 examination and average scores on the five picture problems.

9.5.2. Age

Two African studies on achievement, one in Uganda and one in Kenya have taken age as an independant variable. In Kenya, Thias & Carnoy (1969) examined the determinants of students as measured by performance of over 3000 candidates in the Kenya Preliminary examination in 1967. They found that the younger the candidates the higher the score in the examination. In Uganda, Heyneman *et al* (1977) used scores in the Uganda school selection examinations in English, mathematics and general knowledge to analyse *inter alia* the effect of age on the performance of over two thousand grade seven students. They found age was inversely related to achievement (Schiefelbein & Simmons 1978, p.36). This finding supports what Thias and Carnoy had discovered in Kenya (Alexander & Simmons 1975, p.13).

In the administration of the battery of tests for the present research all the standard 7 students were asked for various personal details including date of birth. From this the student age as on June 1st 1987 was calculated and the figures given in Table 9.18. For comparison the average ages of the students who were interviewed as well as the ages of the ones scoring A or B in the five picture problems (described in the table as "good at maths") and the ages of the ones scoring D or E in the five picture problems (described as "poor at maths") are given.

Table 9.18. <u>Average ages of std 7 students</u>

GROUP	N	AVERAGE AGE
Total Population	584	16,2 years
Interview Sample	60	16,4 years
Students good at maths	15	15,5 years
Students poor at maths	19	16,8 years

The average age for the students good at maths is just over eight months less than the population average and that of the students poor at maths is six months more than the average for the population. There is a gap of fourteen months between the two groups.

In order to examine the relationship between age and performance in the maths tests, correlation coefficients were calculated for the same two groups as described above as "good at maths" and "poor at maths". The figures are given in Table 9.19.

Table 9.19. Linear correaltion coefficient for age - maths

SCHOOL	N	R r	SIGNIFICANCE
Keledi	20	-0,4540	$p < 0,05$
Matale	6	+0,0481	none
Mafenya	8	-0,0221	none
Total population	34	-0,2577	none

A small inverse relation was found for Keledi students but no statistically significant correlation was found for the other two schools.

The relationship between age and scores on the interview picture problems was also examined as shown in Table 9.20.

A fairly high inverse relation was found for Keledi students and also a small overall correlation for the total population but the coefficients for Mafenya and Matale are not statistically significant.

Table 9.2u. <u>Linear correlation coefficient for age - interviews</u>

SCHOOL	N	r	SIGNIFICANCE
Kr' di	20	-0,5455	$p < 0,02$
Matale	6	-0,4778	none
Mafenya	8	-0,1376	none
Total population	34	-0,3798	$p < 0,05$

Finally in order to find out if there was any relationship between age and GEFT scores a 10% sample of boys and a 10% sample of girls was drawn at random from the 153 students who did the GEFT test. The two groups of 16 each were then analysed by comparing the scores on the GEFT and their ages as given in Table 9.21.

Table 9.21. <u>Correlation between age and GEFT scores</u>

	N	r	SIGNIFICANCE
Boys	16	-0,5709	$p < 0,02$
Girls	16	-0,3427	none

The correlation between age and GEFT scores is significant at 0,02 level for boys but not statistically significant for girls.

What emerges from the above discussion is that age of students is a factor probably related to performance in maths but the nature of the relationship is not clear. Age may likel depend on the socio economic status of the family in that a well off family may be able to provide students with school books, school fees, place and time for private study as well as expressed interest in the students school work and stimulation of extra curricular activity such as visits to cities and other places. A student from a poorer background won't have all these supports and may be forced to miss school because of lack of funds or even if that doesn't happen he will tend to be occupied during the evenings and at weekends with chores such as fetching water and firewood, cooking and washing and consequently have less time for homework and private study.

9.5.3. Sex

Sex and age of students were among the variables examined by the International Association for the Evaluation and Achievement (I.E.A.). In a seven year study in 23 countries, student achievement in six subjects was studied and the findings showed that the sex of a student explained only 2% of the variance. On average it tended to be higher for the less well developed countries (Alexander & Simmons 1975, p.40). The study of Beebout (1972) in Malaysia found that the sex of the student had a consistent impact on achievement. The better performance of females in this study reinforces U.S. and other research e.g. the Carnoy-Thias (1974) study done in Tunisia (Alexander & Simmons 1975, p.36). It is dangerous however to generalise these findings because what may be true for languages or social sciences need not necessarily hold for mathematics and the physical sciences. In fact the I.E.A. study reffered to above found that girls performed worse than boys in science achievement in nearly all 23 countries researched.

Heyneman _et al_ also found that sex was positively correlated with achievement in Uganda (Schiefelbein & Simmons 1978, p.37).

Reporting from work done in Rhodesia Freer (1973) claims that sex bias is indeed a variable in primary education and it favours girls. It is principally in reading that girls are advantaged in the primary school however the differences seemed to be ironed out at the high school level.

When the number of boys and girls who performed well in the five picture problems was counted it became clear that many more boys were in the group who scored A or B on average while the group who scored D or E had many more girls. The figures are given in Table 9.22.