

https://dspace.org/

The teaching of mathematics in Soweto secondary schools through ' Creative Maths' (Malaysian) and 'Maths the Easy Way' (DET) programmes: a comparative study

Letho, Paul

2014-05-19
http://hdl.handle.net10539/14674

Downloaded from a DSpace repository. https://dspace.org/

THE TEACHING OF MATHEMATICS IN SOWETO SECONDARY SCHOOLS THROUGH 'CREATIVE MATHS' (MALAYSIAN) AND 'MATHS THE EASY WAY' (DET) PROGRAMMES : A COMPARATIVE STUDY

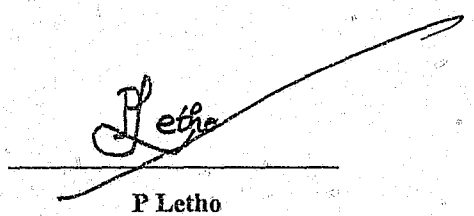
Paul Letho

A Research Report submitted to the Faculty of Education, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Education.

Johannesburg, 1998

DECLARATION

I declare that this research report is my own, unaided work. It is being submitted in partial fulfilment of the requirements for the degree of Master of Education at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.



P Letho

02 day of June 1998

ABSTRACT

This study used a two-group, cross-over controlled experimental design to investigate which training programme best succeeds in improving student performance in mathematics. In this investigation two training programmes were compared both quantitatively and qualitatively in the analysis of the results. The **Malaysian** 'Creative Maths' (a foreign programme) and the **DET** 'Maths the Easy Way' (a local programme) were tested against each other in the teaching of mathematics basic sets theory using the small-group and whole-class teaching methods respectively. A sample of **40** students matched by age, sex, exposure to mathematics and the same social background was selected by randomisation out of a population of **135** from 'Rewutlwile' Secondary School in Soweto to participate in this study. After selection students were divided and assigned to two groups of **20** participants each, termed control and experiment. Two mathematics teachers from this school volunteered to serve as group-tutors in this experiment in order to teach mathematics basic sets theory through these abovementioned programmes. They were highly qualified and of the same age group, sex and teaching experience. A **Pre-Test** and **Post-Test 1** and **2** were all used as data gathering instruments. The quantitative/statistical data gathered were then analysed by means of **Non-parametric tests** - the Sign Test (Test of Effect of Treatments) and the Wilcoxon Matched-Pairs Signed-Ranks or Mann-Whitney U test (Test of Difference Between the Treatments). The students' scores obtained from the tests administered were compiled, analysed and matched against each other as averages within the respective groups. Questionnaires, interviews and classroom observations served as necessary instruments in gleaning qualitative data used strictly to supplement these experimental data. This investigation revealed that both programmes were effective in teaching 'sets' and in applying the teaching methods. However, 'Creative Maths' (known as **Training Programme E**) was slightly more effective statistically than 'Maths the Easy Way' (known as **Training Programme C**) but this difference was not much. Because the former programme was effective at the **10% level** and the latter at the **5% level**, quantitative data proved that 'Creative Maths' had a slightly higher effect in improving student performance in comparison with 'Maths the Easy Way', and that small-group teaching (through 'Creative Maths') was slightly more effectively used in the teaching of mathematics basic sets theory than whole-class teaching (through 'Maths the Easy Way'), whereas it was qualitatively proved that there were more positive perceptions held about 'Creative Maths' than 'Maths the Easy Way' for improving student performance, i.e., the former was conceptualized as having a high potential for improving performance compared with the latter.

ACKNOWLEDGEMENTS

I wish to thank the Departments and the people who have contributed to this research project. They are ...

The Education Department, University of the Witwatersrand, in particular Dr Ray Basson for his supportive role as both supervisor and advisor during the entire period of this project. I am indeed most grateful to him for his help in the initial stages of research, for his advice and ideas concerning the data obtained, and for his careful reading of the entire final draft of this research report. It was wonderful of him to do that.

P Fridjohn in the Statistics Department, University of the Witwatersrand, for his role and involvement in advising about the analysis of the measurement data needed for this research project. Indeed he was marvellous and helpful to me.

Patricia King for her outstanding capability and efficiency in typing this research project. She is dedicated and skilful and her patience is enormously appreciated.

Not forgetting the school, students, teachers and officials who made their time available to participate in the study. I sincerely thank them and appreciate greatly the seriousness, devotion and enthusiasm they all have demonstrated in whatever their roles were in making this study a success.

TABLE OF CONTENTS

DECLARATION		ii
ABSTRACT		iii
ACKNOWLEDGEMENTS		iv
TABLE OF CONTENTS		v
LIST OF ABBREVIATIONS		viii
LIST OF TABLES		ix
LIST OF FIGURES		x
CHAPTER ONE		1
1.	**INTRODUCTION**	1
1.1	**Purpose**	1
1.2	**Rationale**	1
1.3	**The Two Mathematics Training Programmes of this Study**	6
1.4	**Proposed Research Statement**	8
1.5	**Research Questions**	8
1.6	**Explanation of the Terms**	9
CHAPTER 2		11
2.	**RESEARCH METHODOLOGY**	11
2.1	**Quantitative Method**	11
2.1.1	Training of Participating Teachers	12
2.1.2	Control of Variables	13
2.1.3	Research Sample	14
2.1.4	Sampling Procedure	16
2.1.5	Matching Procedure	17
2.1.6	Methods for Analysing Statistical Data	19
2.1.7	The Two-Group Cross-Over Design	19
2.1.8	The Criteria for this Study	22

2.1.9 Tests 22

2.2 Qualitative Methods 23
2.2.1 Questionnaires 24
2.2.2 Interviews 24
2.2.3 Classroom Observation 25

CHAPTER 3 27

3. LITERATURE REVIEW 27

3.1 Introduction 27

3.2 The Small-Group and Big-Group Model 28
3.2.1 Timetabling 29
3.2.2 Staff Allocation 29
3.2.3 Venues 29
3.2.4 Teacher and Student Preparation 29

3.3 Exploration of Small-Group Instruction 30

3.4 Themes Enhancing Performance 34
3.4.1 Developing Understanding 34
3.4.2 Language 34
3.4.3 Realistic and Relevant Objectives 34
3.4.4 Small-Group Games 34
3.4.5 Accuracy and Concentration 35

3.5 Conclusion 35

CHAPTER 4 36

4. RESULTS OF THIS STUDY 36

4.1 Explanation 36

4.2 Test of Effect of the Treatments 42

4.3 Test of Difference Between Treatments 42

CHAPTER 5 45

5. DESCRIPTIVE DATA 45

5.1 Observation of Group Classes 45

5.2	**Questionnaires**	48
	5.2.1 Student Questionnaire (Appendix H)	48
	5.2.2 Teacher Questionnaire (Appendix I)	51
5.3	**Interviews**	52
	5.3.1 Mathematics Teachers Interviews (Appendix J)	52
	5.3.2 DET Officials Interviews (Appendix K)	56
CHAPTER 6		59
6.	**CONCLUDING COMMENTS ABOUT THE MATHEMATICS PROGRAMMES**	59
6.1	**Introduction**	59
	6.1.1 On 'Which' Programme Do Students Perform Best in Mathematics: 'Creative Maths' or 'Maths the Easy Way'?	59
	6.1.2 What Perceptions Are Held About 'Creative Maths' in Comparison With 'Maths the Easy Way' for Improving Student Performance?	59
6.2	**Comments on the Research Question: On 'Which' Programme Do Students Perform Best in Mathematics, 'Creative Maths' or 'Maths the Easy Way'?**	59
6.3	**Comments on the Research Question: What Perceptions Are Held About 'Creative Maths' in Comparison With 'Maths the Easy Way' for Improving Student Performance?**	62
6.4	**Significance of 'Creative Maths' and 'Maths the Easy Way'**	63
6.5	**Conclusion**	63
REFERENCES		65
APPENDICES		71
PRE-TEST AND POST-TESTS		84

LIST OF ABBREVIATIONS

NGOs	=	Non-Governmental Organisations
BSc	=	Bachelor of Science
BEd	=	Bachelor of Education
DET	=	Department of Education and Training
Treatment E	=	The Experimental Group participating in the study
Treatment C	=	The Control Group participating in the study
TIMS	=	Third International Mathematics Study
2nd ed.	=	*Second Edition*
3rd ed.	=	Third Edition
Std. Dev.	=	Standard Deviation
Min. Val.	=	Minimum Values
Max. Val.	=	Maximum Values

LIST OF TABLES

Table 1:	Mathematics Registration Statistics	15
Table 2:	Students Chosen to Participate in the Experiment	16
Table 3:	The Three-Group Design	20
Table 4:	Teacher-Student Advantages	29
Table 5:	The Two-Group Cross-Over Design Involving the Experimental and Control Groups	37
Table 6:	Results of the Experiment Under Treatments C and E, Illustrating the Scores of the Pre-Test and Post-Test 2	38
Table 7:	Results of the Experiment Under Treatment C and E, Illustrating the Scores of the Pre-Test and Post-Test 1	39
Table 8:	Normal Distribution of the Test Scores	42
Table 9:	The Effect of Treatments C and E	43
Table 10:	Students Responses to the Questionnaire	49
Table 11:	Differences of the Mean Values	61

LIST OF FIGURES

Figure 1:	Mathematics Scores	2
Figure 2:	Dot Patterns	53
Figure 3:	Schematic Representation of Comparing and Matching Student Scores	60

CHAPTER ONE

1. INTRODUCTION

1.1 Purpose

This study compared the teaching of mathematics based on 'sets theory and concepts' in an experimentally controlled cross-over design of two mathematics programmes, namely 'Creative Maths' (Malaysian) and 'Maths the Easy Way' (DET). The purpose was to establish on 'which' programme do students perform best in mathematics, and what perceptions are held about these two mathematics programmes in comparison with each other for improving student performance.

1.2 Rationale

There were several reasons why this study was conducted.

One, research based on mathematics indicated that South African pupils always came last out of a class of about half a million teenagers worldwide who took the Third International Mathematics Study. South Africans notched up the lowest average marks in mathematics compared with other countries. For example, in mathematics, the average South African score was the same as, or worse than, the lowest 5% of scores in all but a handful of the other 40 countries. The average South African Standard 7 student tested answered just 25% of the mathematics questions correctly compared with world averages of 55%. It was felt that South Africa was bottom of the class with regard to mathematics ability and performance based on the comparison of these 41 countries given in Figure 1. This survey claimed that South Africa was among the world's worst in mathematics; that none of our Standard 7 pupils scored enough points to make it to the top quarter internationally and only 2% earned enough marks to put them in the top half. For this reason this situation ought to be improved by adopting a new curriculum or testing foreign programmes against local programmes and establishing in which programmes the students would perform better. Krisch claims that if a proper grounding in mathematics is not received at primary school level, there was every likelihood of the children dropping mathematics at high school (*The Star*, 1997: 2).

Two, newspaper 'news analysis' articles by Gilian (*The Sunday Times*, 1997: 7) hold that more girls than boys wrote the matriculation examination in each province last year, but proportionally fewer girls than boys passed. Fifty-six per cent of full-time candidates were female

Country	Average Score	Country	Average Score
1. Singapore	643	21. Israel	522
2. Korea	607	22. Sweden	519
3. Japan	605	23. Germany	509
4. Hong Kong	588	24. New Zealand	508
5. Belgium (Flemish)	565	25. England	506
6. Czech Republic	564	26. Norway	503
7. Slovak Republic	547	27. Denmark	502
8. Switzerland	545	28. United States	500
9. Netherlands	541	29. Scotland	498
10. Slovenia	541	30. Latvia	493
11. Bulgaria	540	31. Spain	487
12. Austria	539	32. Iceland	487
13. France	538	33. Greece	484
14. Hungary	537	34. Romania	482
15. Russian Federation	535	35. Lithuania	477
16. Australia	530	36. Cyprus	474
17. Ireland	527	37. Portugal	454
18. Canada	527	38. Iran	428
19. Belgium (French)	526	39. Kuwait	392
20. Thailand	522	40. Columbia	385
		41. SOUTH AFRICA	354

Figure 1: Mathematics Scores

Source: *The Star*, 1997: 2 compiled by Fiona Krisch, taken from TIMS.

and 50.2% passed; 44% were male and 58.5% passed. Generally it would seem amongst other subjects mathematics was of great concern in not producing good results. For example, Gilian asserts that 23 in 100 full-time candidates wrote science last year compared with 80 in 100 who wrote biology. Nationally, pupils scored well in these subjects: 67% passed science, and biology

had a pass rate of over 60%. However, mathematics was not a hot favourite. There were problems in the pass rate. Only 41% cut of every 100 matriculation candidates wrote the examination and just less than half passed. This situation needed improvement through more research work (*The Sunday Times*, 1997: 7). Overall, the national pass rate in 1996 was 54.7%. Ranked in order of percentage pass rates were: North West 96.6; Western Cape 80.2; Northern Cape 74.1; Kwazulu Natal 61.8; Gauteng 60.6; Free State 51.1; Eastern Cape 49; Mpumalanga 47.4; and Northern Province 38.8 (*Sunday Times*, 1997: 7).

Three, the investigative mode in mathematics was either lacking or never sufficiently explored. Students were not sufficiently encouraged to investigate and discover ideas for themselves, to look for interesting patterns and relationships, and to develop their own generalizations. New and fascinating topics ought to be explored not solely for their mathematical value, but also because they stimulated interest and motivated students to put forth their best efforts. This was because of the need to teach mathematics successfully and effectively. This need was reflected in the beliefs to which mathematicians were committed: that there were fundamental mathematical concepts which could be isolated and set forth with sharpness and clarity; that these concepts when truly understood, could provide powerful tools for extending knowledge; that students of every level should be encouraged to actively participate, to think, to question, and to seek understanding; and that concepts should be exciting and stimulating in mathematics classrooms, as stated by Clement et al., (1981:289).

Four, the failure rate in mathematics classrooms in South Africa is appalling. School mathematics was identified as a gatekeeper that prevented many students from pursuing further education. Mathematics students found themselves unable to cope with mathematics and not able to do it after registration in the primary and secondary phases. This posed a very serious problem because it would seem that indeed there were various factors in the education system that gave rise to such problems. One of these major problems lay in the teaching of mathematics and hence the failure rate, students underachieving and poor performance in mathematics class rooms. Lund (1990: 1) claims that many of the African pupils who wrote their November matriculation examination in 1983 will always recall that year as 'the year of tears and disaster'. No more than 9.8 per cent of the 72 168 candidates who wrote matric achieved matriculation exemption, with only 7 109 qualifying for university admission. Of the 25 350 students who wrote mathematics, only 10 400 students obtained clear passes and 14 950 failed. The latter figure was very shocking

because it represented a very high proportion of unsuccessful students in mathematics. That was why I decided to undertake a study based on comparing mathematics training programmes which would be crucial in relation to which programme best succeeded in improving student performance. South Africa as a country had many mathematics programmes used by NGOs and many other organisations but it could not be said with accuracy how many of these programmes were successful in improving student performance. The only way to find out is perhaps to investigate the situation by conducting research.

Five, Ellerton and Clements (1989: viii) assert that school mathematics in virtually all countries around the world was tried in the balance and found wanting. Fundamental changes were required and these were: a need for a reconceptualisation of what school mathematics should be about (the 'why'), what mathematics should be studied in schools (the 'what') and how mathematics should be represented and assessed (the 'how'). Several calls have been made through research for school mathematics to reform its ways. In South Africa, many NGOs including the present Ministry of Education have attempted to mount major programmes to develop problem-solving curricula, activity-learning programmes and real-life approaches. There has always been a demand for greater learner understanding, greater involvement and greater ability to apply concepts and skills outside the classroom. There was a great wish by both students and teachers to achieve well in the learning and teaching of mathematics. But if one could believe various media reports from around the world asserting that standards have fallen in the teaching and learning of mathematics, then all this was to no avail. While the basis of such reports could almost be questioned, there could be little doubt that in many countries there was a massive public dissatisfaction with school mathematics. Yet at the same time, there was a continuing conviction that mathematics was important. Clearly, far-reaching action was called for and this research serves to address such a need.

Six, Nordin's mathematics training programme was used successfully in Malaysia. It was used to teach mathematics concepts and skills practically, creatively and productively. According to Nordin (1990: 210) this programme attracted over 10 000 underperforming students in mathematics - 8 000 of these students (i.e., 80%) passed with distinctions or 'A' passes, 1 000 (i.e., 16%) of this total obtained 'B' passes, while the rest (i.e., 4%) attained clear passes and the lowest-ranked student in this category scored 50%. This demonstrated the effectiveness of the programme, used for disadvantaged students with potential in the rural areas of Malaysia. Nordin

(1990: 145) also claims that learning through small-group formats has shown over 80% of students attaining a level of achievement normally attained by 20% of students under large-group teaching. It followed that a sensible and logical thing to do was to experiment with such foreign programmes to determine how effective they could be in improving student performance locally. That was basically the reason why 'Creative Maths' and 'Maths the Easy Way' were compared experimentally in this current study. The programme used by Nordin in Malaysia was called 'Creative Maths'. The current study should be viewed and understood as the beginning of a wider process aimed at improving the teaching and learning of mathematics in South Africa..

The discussion and the reasons above constitute the rationale of this current study. The concerns presented thus were not new in the area of mathematics teaching and learning, methodology and research. School mathematics has been a long standing problem, and simplistic solutions, formulated by politicians, education administrators, international education agencies and test experts, etc., were put in place by Nordin's study (1990: 143). Mathematics curricula developed in 'advanced' countries were translated, virtually intact, to 'developing' countries, as if there was no doubt that the discipline of mathematics was an entirely language- and culture-free phenomenon. Blanket procedural strategies for change, such as mastery learning, core curriculum and national assessment, were tried, and these succeeded only in exacerbating the problem as claimed by Ellerton and Clements (1989: 150). Subsequently and quite simply, they meant that students were still asked to learn things that they were not ready to learn and in which they had never had any interest.

Greater use of external examinations and tests was always appealing to a section of the public as one way of assuring that 'the basics' would be mastered, but the truth of the matter was that not all students could achieve this because the mathematics programmes used did not always ensure this. On the one hand African students, the majority of whom came from the working class, have not survived. Only a few have survived and that group came from the middle-class, who learned that they were the 'chosen few' and theirs was the prize, for they could do mathematics, arguably because the mathematics was 'theirs' by design. The fact remains that the reality of our current South African situation is that the government (and others elsewhere) want improvement in mathematics education. Why? It is because they see this as important to economic growth and stability, however, they have little idea about how to achieve this desired improvement. There is, for example, a tendency to adopt short-term solutions, often funded by

a re-allocation of resources rather than additional education funding, and to appoint numerous enquiries and committees (even though their recommendations were seldom implemented in a coherent way). For example, Ellerton and Clements (1989: 152) assert that in March (1988) the Minister responsible for tertiary education in Victoria, Australia, Mr Ian Cathie, acknowledged this point in relation to reports on teacher education when he opened a seminar conducted by the Mathematical Association of Victoria. Often these problems are common to mathematics teaching in South Africa.

By improving student performance in mathematics in general, mathematics education would improve. An appropriate action to take now that performance in mathematics was at stake, would be to conduct research of this nature, that is, research that tested foreign programmes against local programmes to determine how they compared in terms of improving performance. This process could take us on the route to success. For example, issues such as the need for the supply of foreign mathematics teachers and the declining pool of mathematics students could be things of the past. In other words, our local students would not be disadvantaged by factors such as a need to increase the supply of qualified mathematics teachers or funding programmes that would improve or alleviate this problem and others such as the dwindling numbers of mathematics students. Because this research was important within the context of this rationale, it was conducted as planned. Graham (1988: 119) and Hunting (1987: 29) are among those who argue that time spent on mathematics is an important issue in access, success and improvement in mathematics.

In conclusion, the idea in this section (i.e., rationale) was to state the reasons necessary for conducting this study concerned with comparing 'Maths the Easy Way' and 'Creative Maths' to determine which programme succeeded in improving student performance, and to establish students' perceptions with regard to the efficacy of these two programmes in Soweto schools.

1.3 The Two Mathematics Training Programmes of this Study

This current study employed two mathematics training programmes, 'Creative Maths' and 'Maths the Easy Way', a Malaysian and a South African programme respectively. The former programme is claimed to have the potential and proven success to help under-achieving students in mathematics basic skills and concepts, to improve and perform better. It was designed by a mathematics educator, Nordin (1990: 210), to address the problems of under-achievement and

poor performance in mathematics in Malaysia. It is described as a programme which was adequate and successful in enriching and empowering mathematics students in their abilities of computing mathematical problems and situations, developing them cognitively to think critically in the way they approached and solved mathematics-related problems. This Malaysian programme involved mathematical activities aimed to increase student participation, motivation, interest, understanding and the meaning of mathematical concepts. The activities were directly related to the programme in the sense that they were not only accessible to mathematics learners during the learning-teaching process but they allowed further challenges and were extendable; they called upon students to make decisions that were relevant and constructive and developed their speculating, hypothesising and testing powers, including their ability to interpret data based on mathematics. A teacher who used this kind of programme was expected to be a hard worker and keen learner, capable of adopting a lively and creative approach in his/her teaching that would generate mathematical enquiry from the learners. This programme was adaptable to such diverse teaching situations as ungraded schools, individual or small-group teaching and even whole-class teaching. However, smaller groups often worked more effectively together and allowed ample chance for discussions.

The latter programme was also of educational value to South Africa. It was designed to help DET students to improve their mathematics skills, particularly those from disadvantaged social backgrounds. Its strength was found in its capability to change an African child's attitude towards mathematics and to deepen his/her understanding of mathematics concepts. It promoted in the learners the confidence and ability to be competent mathematical problem solvers. It is claimed to be successful in improving performance and ability to do mathematics. It is, however, structured on whole-class teaching with tasks or exercises given at the end of each chapter as part of the application. These tasks were relevant to the content of each chapter and challenging. They were arranged from the simple to the complex.

Both programmes were thoroughly studied beforehand and a section based on 'sets concepts and theory' was chosen for this study. The teaching and learning that would take place in the experiment would be based on this content of mathematics. For purposes of this study both programmes ('Creative Maths' and 'Maths the Easy Way') were taught in the experiment using the following subject matter as the main task: Introduction to sets; Elements of sets; Set notation; Using set symbols; Equal and unequal sets; and Equivalent sets. This area constituted

Unit One of both programmes. Unit Two covered Empty (null) sets; Subsets; Universal sets; Venn diagrams; Intersection sets; Union of Sets; and Area on application of sets concepts.

It was on this common content that both programmes were taught and judged. This judgement was based on their 'efficacy' with regard to the teaching of mathematics in the classroom. The teachers used small-groups and the whole-class for 'Creative Maths' and 'Maths the Easy Way' respectively. Although the content covered by both programmes may appear to be the same, the approaches and activities used were totally different, i.e. the methodology was not the same, including the activities. The reason was because in an experiment participants and the programmes compared should be investigated on similar grounds and conditions, as suggested by Bailey (1978: 18). This should be understood as the basic requirement in any experiment.

This study compares the pedagogy of 'Creative Maths' and 'Maths the Easy Way' that is different from each other and measured to establish which programme best succeeds to teach mathematics basic sets theory, even when the syllabus on sets was of the same quality and quantity.

1.4 Proposed Research Statement

A modified cross-over experimental design was used in testing which programme best succeeded in improving student performance in mathematics. In the experiment, two programmes viz., 'Creative Maths' and 'Maths the Easy Way' were compared using small-group and whole-class teaching respectively. The differences in pupils' scores were measured, recorded and compared during the process of teaching and learning based on sets theory and these differences were attributable to the difference in pedagogy i.e., small group ('Creative Maths') and whole-class ('Maths the Easy Way') teaching.

1.5 Research Questions

1.5.1 On 'Which' Programme Do Students Perform Best in Mathematics: 'Creative Maths' or 'Maths the Easy Way'?

1.5.2 What Perceptions Are Held About 'Creative Maths' in Comparison With 'Maths the Easy Way' for Improving Student Performance?

1.6 Explanation of the Terms

1.6.1 A 'Modified controlled cross-over design' is a special method used in educational research for comparing student performance based on two programmes. The pupils' scores are measured with respect to their groups i.e., control and experiment and thereafter compared. For example, the average score of the experimental group (RO_1 X O_2) can be compared to that of the first control group (RO_3 X O_4) wherein "X" in both cases represents the experimental treatment. Similarly the average score of the second control group (RO_5 X O_6) can be compared to that of the experimental group and in this way suspect results can be tested before any conclusions are reached. The method was modified to suit the current study and it was a controlled experiment because in any experiment all conditions must be under strict control to ensure that all external factors are eliminated that would threaten the results, as propounded by Solomon (1949: 142) in his study. In the actual experiment there were only two groups, viz., the control and the experiment.

1.6.2 'Small-group teaching' involves a process wherein the teacher deliberately withdraws from his/her role of being the focus of attention, directing all efforts towards students taking control of their own learning whereas in **'whole-group teaching'** students are passive receivers of knowledge. These abovementioned methods were used in the study to teach 'sets'.

1.6.3 'Student performance' is the way students would respond to questions based on either a test or examination, using grades to establish how well they have done. In this study it was expected that both programmes 'Creative Maths' and 'Maths the Easy Way' would have different effects on student performance. Performance can either be good, average or bad.

1.6.4 'Compared' implies a situation in which two things are considered or judged in relation to each other with the aim of showing differences and similarities. It is in this manner that 'Creative Maths' and 'Maths the Easy Way' were judged. Students involved in both these programmes are expected to be compared on the basis of their grades in mathematics.

1.6.5 'Perceptions' are beliefs or what people would think about 'Creative Maths' in comparison with 'Maths the Easy Way' for improving student performance in mathematics basic sets theory. Perception is thus a natural ability to notice and understand things.

In conclusion, this chapter has established the focus of this current study. Reasons were explained why it was important for the study to be conducted. Underlying the current study were the two specific main research questions that followed the broad research statement described very briefly, followed by the explanation of the terms related to this study. Reasons formed part of the study rationale. The two research questions served as central questions in the study, described or explained what the researcher or study set out to do and, provided a clear focus of the investigation in this study. Research questions in the study helped to clarify the research problem, that is, something that the researcher was interested in and wanted to investigate. Unfamiliar terms were listed and defined.

CHAPTER 2

2. RESEARCH METHODOLOGY

In educational research, methodology is described as the operational framework for gathering and processing data (Durkheim, 1895: 25). This comparative study employed quantitative (i.e. the controlled experiment) and qualitative methods (represented by in-depth interviews and observations of the learning environment and open-ended questionnaires). Each method is described below.

2.1 Quantitative Method

Experimentation in social research is considered by Bailey (1978: 222) as an acceptable method of attempting to demonstrate the existence of a causal relationship between independent- and dependent variables. Whether or not the existence of a causal link between variables can actually be empirically demonstrated or proved is debatable, the logic of experimentation being a matter based on the premise that *it is possible* to establish causality.

In this study causality was established by proposing the two causal hypotheses stated in sub-section 1.5. These hypotheses guide the study. Bailey (1978: 223) claims that any causal hypothesis states that the independent variable causes change in the dependent (effect) variable. In this study the two causal hypotheses were used in measuring the dependent variable by introducing the independent variable (pedagogy) and initially remeasuring the dependent variable (Post-Test 1) to determine the possibility of the resultant change in its value. This procedure was done cyclically. However, that the degree of certainty with which changes in the 'before' and 'after' measures of the dependent variable could be attributed to the tests stimuli is something that depends on the 'degree of closure' in the experiment, described as the extent to which the researcher is able to control the relevant variable or those variables assumed to be relevant, as Bailey asserts (1978: 226). By instituting strict control critical research factors were isolated.

In this study, four forms of control were applied, that is, control of the composition of experimental and control groups, control of the Pre-Test and two Post-Tests, including the level of measurement essential to measure values of the independent variable, control over the environment in which the experiment was set up, and control over the independent (causal) variables. These controls served to preserve the integrity of this study and that the investigation

remained scientifically respectable by ensuring a rigorous design and strict administrative control management accuracy. In this study, generalisations were drawn from 40 students to a wider population, employing laws of probability, at the same time, guarding against picking out 'exceptions to the rule', and incorporating some measure of randomness in the selection of the study sample, i.e., block-pairing participants according to predetermined variables.

2.1.1 Training of Participating Teachers

Two qualified mathematics teachers of the same age group, sex, exposure to mathematics and social background were selected from 'Rewutlwile' school and trained to teach the experimental and control groups of the experiment. This training was aimed at preparing and organising these mathematics teachers for the syllabus and course material to be taught through 'Creative Maths' and 'Maths the Easy Way', using the small-group and whole-class approach respectively, so that a high standard of teaching could be maintained. Step by step training was given to each mathematics teacher to ensure that each knew and understood what would be expected of him with regard to the method of teaching mathematics 'sets concepts and theory' (i.e. basic maths concepts) to both groups in the experiment. This training took the two full months of September and October, 1994. It was done for five days, each week, for two hours. Afternoons were set aside for this purpose so that the training would not interfere with the normal school periods of teaching and learning including other activities. Both trainees had BSc and BEd degrees, were of the same age, sex, experience, social background, and were brought up and resided in Soweto.

The training involved specific procedures of teaching through each mathematics programme. Training was dominated by demonstrations and discussions, including clarification and repetition of action. The trainees were from time to time asked to practise and to do the steps over and over again. This practice gave them a lot of confidence in the task they would be faced with. A lot of concentration was expected from them and the steps were practical and corresponded exactly with the eight items of the main syllabus to be taught. The syllabus covered sets concepts and theory 1 to 8, divided into Unit One (concepts 1 - 4) and Unit Two (concepts 5 - 8). Refer to Appendix A which shows a detailed outline of the structure of the training programmes.

With regard to this training procedure, the trainer (the researcher), first demonstrated the teaching of concepts 1 to 4. This demonstration covered both maths programmes, i.e., 'Creative Maths' and 'Maths the Easy Way'. Thereafter both trainees practised the procedures before the actual demonstrations. Subsequently they would be assessed by the trainer. Similarly concepts 5 to 8 were demonstrated to both trainees, one at a time until they felt confident. Throughout, any problems arising were pointed out and resolved. This training was practical and met the teaching prescriptions contained in 'Creative Maths' and 'Maths the Easy Way'.

Early in January 1995 both mathematics teachers were reminded of their commitment and invited to attend final practice-demonstration sessions which took a week to complete with a pilot group chosen precisely for this purpose from the neighbouring school situated three kilometres from 'Rewutlwile', the school in which the actual investigation of the study was carried out. In February 1995 the actual teaching with the participating groups commenced.

2.1.2 Control of Variables

Certain variables had to be controlled, although it is never 100% possible to exercise complete control over the environment within which the experiment is conducted, according to longitudinal studies in social research (Bailey, 1978: 7).

2.1.2.1 Students were matched according to their grade levels and Pre-Test scores before being randomly assigned by placement to the Experimental- or Control group.

2.1.2.2 Each student from the same group was taught different parts of the same mathematics basic sets theory prescribed in 'Creative Maths' and 'Maths the Easy Way', and each was taught by both teachers to control the 'Hawthorne' (novelty) effect, described by Downing (1967: 25) as an improvement in performance consequent upon participation in an experiment and independent of other factors, presumed to be mediated by motivational changes. In the actual experiment the level of measurement attained was **ordinal**, as explained in **2.1.5**.

2.1.2.3 The 'teacher-effect' indicated by the level of the teacher's interest, ability and motivation in the content was evenly spread amongst the sample since each teacher had the

opportunity of teaching both groups, and had the same qualifications and experience in teaching mathematics in DET schools situated in Soweto.

2.1.2.4 Both the Pre-Test and Post-Tests administered to each student in the experiment were identical in quality and composition. No discrepancies were allowed in their selection, since they were recently constructed and standardised; they were valid tests; and they were appropriate to grade 9 cognitive level. Validity is about the truthfulness of a test. A procedure called 'concurrent validity' was employed to establish the validity of the tests used in the experiment.

If the measures to control this study's variables were strictly applied, it implies that any significant change between the Pre-Test and the Post-Tests would be attributed to the methods of teaching used in the maths programmes 'Creative Maths' or 'Maths the Easy Way'. The investigator strove to control all variables that could affect the relationship between the specified cause-and-effect variables if not controlled. The aim was to provide data that were valid and reliable for statistical analysis. This research is expected to be protected by parametric limitations. As a result the research sample was matched along particular parameters defined on **p.13**, sub-section **2.1.2.1.**

2.1.3 Research Sample

An attempt was made to select the sample randomly by replacement. This sample was drawn from a sampling frame that did not of itself introduce a bias relevant to the subject of inquiry. Students in this sample were matched by their age, sex, exposure to mathematics and social backgrounds. Selection was done from a pool of 135 students aged 15 years and registered for mathematics in 'Rewutlwile' Secondary School. The registration statistics as at 14 January 1995 are indicated in **Table 1** below. Forty students currently registered at 'Rewutlwile' were chosen by randomisation. First, randomisation was preferable in this study because it ensured greater likelihood of equivalence, i.e., of apportioning out between the experimental and control groups of any other factors of the subject that might conceivably affect the experimental variables in which the researcher was interested. Cohen and Manion (1980: 191) suggest that randomisation is one way of controlling for extraneous variables. Secondly, it was thought that

randomisation would be a suitable method for choosing a simple random sample from a larger group, i.e., 40 students chosen from 135 students. Twenty students were randomly assigned to **Treatments C and E** respectively so that each possible sample of that size could have the same chance of being selected. Each subject in the sample was equally likely to receive each of the treatments. The necessity for randomisation in controlled experiments was first pointed out by Fisher (1935: 1). In the context of comparative trials, Hill (1962: 35) describes what was accomplished by the random assignment of treatments to subjects as "ensuring that neither our personal idiosyncrasies ... nor our lack of balanced judgement has entered into the construction of the different treatment groups ..., and that it removed the danger inherent in allocation based upon personal judgement, that believing we may be biassed to exclude it and that in so doing we may over compensate by 'leaning over backward' and thus introduce a lack of balance from the other direction". The sample was reasonably large to enable more accurate predictions.

TABLE 1: MATHEMATICS REGISTRATION STATISTICS

Age	Total No. of Students	Gender		Language Group		
		Male	Female	Zulu	Sotho	Tswana
15	135	75	60	50	33	52

In this study it was decided that since the sample of approximately 30 per cent of the students was chosen at random, it would represent a suitable population of students who belonged to the working-class spectrum and were registered for mathematics in a DET school. This school was situated in Soweto within a reasonable walking distance for participants. As a result no transport problems were anticipated. The school was widely known for its discipline and strong culture of learning and it was amongst the few that were not affected by chalk-downs and boycotts in the 1980s. It was for these reasons that this study was conducted in this school. In the past nobody had ever gone to the school to conduct research on any area and the school had been wanting this to take place so that teachers would be able to measure the quality of their teaching. In fact this research came at the right time to this school.

Two qualified teachers who received training on 'Creative Maths' and 'Maths the Easy Way' methodology were responsible for teaching two groups of 20 students each, 'block-paired' into the experimental and control groups. These groups would be taught mathematics on 'sets

concepts and theory', Unit One based on 'sets concepts and theory' 1 to 4 would be taught first according to 'Creative Maths' and 'Maths the Easy Way', simultaneously. Thereafter students would be crossed-over and receive instruction on Unit Two, covering 'sets concepts and theory' 5 to 8. A Pre-Test would be administered to both the control and experiment simultaneously before any teaching, followed by Post-Test 1 and 2 administered at intervals at the end of the teaching of Unit One and Unit Two respectively. Appendix B represents the student records and statistical data of the Pre-Test.

2.1.4 Sampling Procedure

In choosing the research sample, special letters (see Appendix G) were written to each mathematics student inviting him/her to participate in the study. Reasons were fully stated why the study was important and why they should participate. The principal of the school also confronted the group of students and explained why participating was necessary. The nature of the study, the length of study, the venue, the frequency of participation and the role students were expected to play were all explained and discussed. Some of the letters were sent to the parents requesting them to allow and encourage their children to participate in this study. There were only 40 replies received of positive responses and this represented a suitable number of students who would be part of the sample. **Table 2** shows student participation.

TABLE 2: STUDENTS CHOSEN TO PARTICIPATE IN THE EXPERIMENT

Number of Respondents			Gender		Language Groups		
'Yes' Answers	Neutral	'No' Answers	Male	Female	Zulu	Sotho	Tswana
40	48	37	20	20	10	13	17
Total: 125							

It is important to note there were 48 students with neutral answers and 37 students with 'no' answers. All efforts were made to obtain this sample, however, it could be argued that since the investigator directly/indirectly urged students to participate in this current study, through the principal, teachers and parents, this may contribute to an 'expectancy effect'. This implies that the researcher's expectations might affect the results of the experiment. Additionally, since the

researcher's influence was exercised before the selection of the sample and grouping of students, it might be possible for the researcher's intervention in the experiment to influence results when one group, usually the experimental, becomes aware of the experimenter's expectations, that is, after placement of individuals to experimental and control groups (Rosenthal and Jacobson, 1966: 115). Lastly it could be argued that this sample was selected differentially since participants were randomized, matched and volunteered to participate in the study. For this work to be undertaken successfully, it needed the co-operation and support of all parties concerned. Without their support this study would indeed not have been possible. Translating some of the letters into Zulu, Sotho and Tswana lessened the problems that could have been envisaged in them comprehending English.

2.1.5 Matching Procedure

The method of randomised blocks, i.e., block-pairing of participants as suggested by Tuckman (1978: 441) was carefully employed in the selection procedure. This means that individuals in the study were 'paired' according to certain predetermined variables, namely gender, age, ability and knowledge of mathematics (exposure) and social background. Each separate matched-pair was then randomised to either the Experimental or Control group by replacement. This procedure was followed to ensure that a suitable sample was chosen for this study and that conditions of a cross-over design were met.

Student scores were expressed in percentages and averages worked out according to the total number of items responded to correctly, expressed over the overall total of items expected to be answered. The scores were obtained from the Pre-Test and Post-Test 1 and 2. The Pre-Test was written before the commencement of any teaching. Thereafter it was marked, checked and rechecked by the markers (i.e., the mathematics teachers) and then percentages and averages were calculated. The Post-Tests were written one at a time at intervals, only after a lengthy period of treatment. Both tests served as instruments in determining student performance in mathematics. Percentages and average scores of individuals were then matched within their groups at only one grade level. Comparisons were drawn from this matching and the results were obtained from matching individuals scores. Further comparisons were made by matching the total average scores per individual student and the sum-total average scores of Post-Test 1 and 2 with each other and further matching them to the Pre-Test. It is for these reasons matching was

important as a means of comparing results based purely on student averages and means per area taught and tested. It was assumed that it is on these grounds that the research questions would be assessed if and only if student scores were matched and ordered according to grade levels and the relative sizes of an increase or change in improving student performance in the teaching of mathematics 'sets theory and concepts' through 'Creative Maths' and 'Maths the Easy Way', using small-group and whole-class teaching methods. The level of measurement attained as such was *ordinal* because the differences between individual student scores were interpreted according to their direction and relative size of changes in scores of other students within the same grade level (that is first pair, second pair up to the twentieth pair) out of 40 volunteers of the sample. It was not *cardinal*.

It must be noted that developing such research instruments within this framework of interpreting results was not an easy task. These instruments required careful development and did not necessarily spring to hand in a perfect form. They were fully adapted to the particular investigative task. For example, all formal texts on research methods mention the desirability of a 'pilot study' because that is one way of honing the research instruments to their particular task. Thus trying out a research instrument on a sample of respondents with similar characteristics to those of the intended target/survey population may for instance quickly and reasonably reveal gaps in the logical sequence of testing or questioning, or the incomprehensibility to the respondents of the wording used. This also applied to other data-gathering instruments used in this current study (questionnaires and interviews). All research instruments employed in this study were first tried out with other students belonging to the neighbouring schools around Soweto, outside the school used in this study and not with the actual sample selected for purposes of the current experiment. The aim was to determine their effectiveness and find loopholes first, before they could be applied to the actual sample of this current study. It was a necessary step, taken as part of planning the research.

After long sessions of testing and retesting pupils who belong to schools around Soweto using the Pre-Test and the two Post-Tests designed for the actual experiment indicated the same nature of results based on individuals scores of participants were obtained. This implies that there was validity in the tests that could be attributed to the degree to which what was measured corresponded with other independent measures obtained by different research tools. To an extent

they were reliable owing to the extent to which the same results were obtainable when a different group was tested (Henwood et al., 1992: 97).

2.1.6 Methods for Analysing Statistical Data

Having considered the problems of internal validity, the instruments for analysing statistical data were carefully selected. Non-parametric statistical procedures were employed for analysis of performance data generated by the comparative study because the sample was not large enough and these tests provide a suitable method for comparing gain scores as a way to determine the effects the maths programmes have on the teaching of basic sets theory (Siegel, 1956: 76). The study used:

2.1.6.1 ***The Sign Test***: to establish the direction of the differences within-pairs exposed to the alternative forms of teaching, i.e., small-group versus whole-class (Siegel, 1956: 68).

2.1.6.2 ***The Wilcoxon Matched-Pairs Sign-Rank Test*:** to test the relative magnitude of within-pair differences at a particular grade level (Siegel, 1956: 75).

Everything possible was done to prepare for the event to be observed in the experiment, namely two contrasting pedagogies (small-group and whole-class) in the teaching of mathematics. These instruments above were chosen to adjudicate the respective *efficacy* of one programme in relation to another. Both tests were vital in analysing statistical data in the study.

2.1.7 The Two-Group Cross-Over Design

According to Verhonick and Seaman (1978: 30) the concept and purpose of design in research methodology is understood as the plan, strategy and structure of conducting a research project, providing the overall framework for collecting data and a format for the detailed steps in the study that always depended upon the broad statement of the problem. See section 1.4.

The design for this current study is similar to the one adopted by Solomon (1949: 137) in his study. The only difference is that he uses a Three-Group design without crossing-over the subjects in his sample whereas this study used a Two-Group Cross-Over design in the experiment whereby the subjects in the Experimental and Control groups were crossed over. The idea here

was to obtain more reliable and effective results by simply switching over the subjects in their respective groups. A Three-Group design provides all that the Pre-Test/Post-Test Control Group design does by the way of control, but in addition, it enables the researcher to test further whether the Pre-Test exercised any significant influence on the overall performance in the Post-Test situation, so is the two-group cross-over design. But, instead of having to stop at that particular point of the Post-Test situation, it went further to provide an opportunity to the researcher of crossing his/her subjects in their respective groups and giving them a further treatment followed by a Post-Test situation, i.e., a stage or level that would enable results (scores) to be compared and within-pair differences to be drawn in terms of direction and relative magnitude. It is argued that this current study adopted a more reliable method in the design that was likely to bring more effective and valid results than in Solomon's case/situation.

Suppose, for example, it was found that the average score of the experimental group (i.e., Pre-Test) (see top line in **Table 3** below) was significantly greater than that of the first control group (i.e., Post-Test 1). Could it be concluded that this effect was entirely due to the experimental treatment X, or could it possibly have resulted from an increased sensitisation among the experimental subjects as a result of the Pre-Test? The average score of the second control group (bottom line) enabled us to test our suspicion. If the average score of the second control group (i.e., Post-Test 2) was also significantly greater than that of the first control group, then it would be safe to conclude that the Pre-Test itself did not exercise any sensitising effect upon the experimental subjects. In the research, Harvey and Cooper (1978: 14) tested for a Pre-Test *sensitisation effect* on the second, third and fourth year junior school pupils randomly assigned to experimental and control groups in a Solomon three-group design. The results provided conclusive proof of a lack of Pre-Test sensitisation. Note that this explanation above does not necessarily represent the actual comparison in **this** study. A slightly different approach was followed.

TABLE 3: THE THREE-GROUP DESIGN

Experimental (Pre-Test)	$R0_1$ X 0_2	(Top line)
1st Control (Post-Test 1)	$R0_3$ X 0_4	(Middle line)
2nd Control (Post-Test 2)	$R0_5$ X 0_6	(Bottom line)

In the current study, the Pre-Test and two Post-Tests were the key elements used in the two-group cross-over design to determine the effect of the increase or drop in the rate of student performance. The Pre-Test was administered to the experimental and control groups first, before the first treatment was applied. The average scores of these two groups were then calculated and compared with the average scores of the first and second tests. In other words Post-Test 1 was administered to the groups at the end of the first treatment period. Post-Test 2 was administered at the end of the second treatment period. The average scores of the groups of the first treatment period were then calculated on the basis of the direction of within-pairs differences as well as the relative magnitude of within-pair differences. So were the average scores of the second treatment situation. The effect in the teaching of mathematics 'sets concepts and theory' in 'Creative Maths' and 'Maths the Easy Way' could result in either an increase or a drop in performance of the experimental group compared with the control group. Even if it was the case that the groups above were crossed over at some point in the experiment this 'effect' described as the change in performance would still be judged on the basis of whether it was an increase or a drop. Further comparison involved comparing the average scores of Post-Test 1 with those of the Pre-Test followed by comparing the average scores of Post-Test 2 with those of the Pre-Test, a particular situation wherein the Pre-Test was regarded as the experiment and Post-Test 1 and 2 served as 1st and 2nd control respectively. If the average scores of the Post-Test 1 were significantly greater than those of the Pre-Test at the end of the first treatment period, this situation would be tested further by administering Post-Test 2 at the end of the second treatment period. The average scores of Post-Test 2 would also be compared to those of the Pre-Test. Thus if the results of Post-Test 1 indicated an increase and those of Post-Test 2 a further increase then it would be concluded that the 'effect' of an increase in performance was due to the teaching of mathematics 'sets concepts and theory' to the groups involved; and if it was further observed that there was a significant difference in performance between the sample groups in terms of Post-Test 1 and 2 situations due to the former scores being greater than the latter scores, then it would be safe to say that 'Creative Maths' was better in comparison with 'Maths the Easy Way' in the experiment. This would lead to the idea that the 'Creative Maths' programme improved student performance best when compared with 'Maths the Easy Way'. It was thought that students would perform best in 'Creative Maths' in comparison with 'Maths the Easy Way'. Refer to **Table 4** which provides the picture of how this study design was executed in the actual experiment. However, the

possibility of the programmes not clearly showing any great significant difference should not be ruled out. Anything can be possible in an experiment of this nature.

In this study the scores were not slightly higher to enable the researcher to make the statistical claim that one programme was better than the other in improving performance.

2.1.8 The Criteria for this Study

For purposes of this study certain criteria were employed by which the results would be tested. These criteria were suggested by Leedy (1989: 83) and Zolkov (1986: 96) for purposes of social research and are discussed below:

2.1.8.1 *Replication*: This study is able to be replicated by any competent researcher, i.e. its problem could be redressed collecting the data under the same circumstances and within the identical parameters in order to achieve results comparable to those secured in the replicated study.

2.1.8.2 *Measurement*: Data in this current study were susceptible to measurement, however, although this is usually accomplished easily in the natural sciences, it was not that easy with the current study. The process which involved quantifying, measuring and evaluating critical factors was difficult and challenging. Generally in the humanities and social sciences, measurement can never be as precise as in the natural sciences.

2.1.8.3 *Control*: Threats to internal and external validity were controlled. This control enabled this study to be conducted within an area sealed-off by given parametric limitations; this helped isolate all factors critical to the study; and ensured replication and consistency within the design.

2.1.9 Tests

In research either parametric or non-parametric tests can be used, depending on the study objectives. Siegel (1956: 19) is of the opinion that parametric tests are more powerful than non-parametric tests, and should be used preferably but with caution to meet all conditions of a particular statistical model. This implies its conditions must be satisfied before any confidence can

be placed in any probability statement as obtained by its employment. In addition the model and the measurement requirement must specify those conditions as clearly as possible.

Additional instruments employed in this study were the Pre-Test and Post-Test 1 and 2. They were expected to be reliable and consistent, after they were validated with former grade 9 groups of neighbouring schools in Soweto, for research purposes. Bailey (1978: 73) and Cates (1985: 124) assert that reliability refers to the consistency with which an instrument produces equivalent scores whether administered twice to the same subject or to two subjects of equivalent talent and experience, in other words measurement does not change when the measured concept remains constant in value. The tests were expected to be valid, that is, they measured what they claimed to measure (Kerlinger, 1986: 417). The validity of a measuring instrument is described by Selltiz *et al.*, (1976: 168) as the extent to which differences in scores on it reflect true difference among individuals on the characteristics we seek to measure, rather than constant or random errors. It is also important to point out that reliability of the tests was obtained by 'test-retest reliability' procedure whereas their validity was obtained by 'concurrent validity' procedure with a pilot group of Soweto schools, done earlier. The write-up of results in this study was guided by statisticians in the Department of Statistics, University of the Witwatersrand.

2.2 Qualitative Methods

Qualitative methods were decided upon because the focus and objectives of the investigation were already very clear. They were preferable in practice because the investigator found them very suitable for collecting data and had cumulative expertise in them. The methods above were employed to supplement the quantitative method discussed in this current study. Their purposes were to tailor the subject of this study and to provide further information helpful in the interpretation of the measurement data obtained using well-tried research techniques and procedures. This current study used three methods, namely, open-ended questionnaires, in depth interviews, and classroom observation on the learning environment. In other words this study encompassed multiple sources of data collection (triangulation) as a means of dealing with variability, as asserted by Henwood et al., (1992: 99). The reason was because triangulation was able to provide a *validity check* on variability. Findings in the study were meant to be descriptive and interpretive. Within this context the investigator's aim was to generalize from the research sample to a wider population, using the laws of probability. The results obtained through the

methods above were not subjected to statistical analysis since they were intended only to inform this comparative study. What was done in this section is described below.

2.2.1 Questionnaires

Open-ended questionnaires were administered to students participating in this study to determine their attitudes to the teaching of mathematics 'sets concepts and theory' through 'Creative Maths' and 'Maths the Easy Way' using the small-group and whole-class approach respectively as well as mathematics teachers participating in the study to determine their opinions about which programme improves student performance in mathematics, i.e., 'Creative Maths' and 'Maths the Easy Way'. It was believed that by gathering questionnaire data on the teaching of mathematics 'sets concepts and theory' through 'Creative Maths' and 'Maths the Easy Way', it would assist in establishing answers to the two main research questions restated as:

2.2.1.1 On 'Which' Programme Do Students Perform Best in Mathematics: 'Creative Maths' or 'Maths the Easy Way'?

2.2.1.2 What Perceptions Are Held About 'Creative Maths' in Comparison With 'Maths the Easy Way' for Improving Student Performance?

Refer to Appendices H and I for the questionnaires used in the study. The data emanating from the questionnaires were analysed to provide answers to the research questions.

2.2.2 Interviews

Interviews were conducted in addition with the two mathematics teachers and DET officials to determine their attitudes towards the two maths programmes, namely 'Creative Maths' and 'Maths the Easy Way' to determine 'which' improves student performance? In the study the teaching of mathematics was based on whether or not student performance was improved using the two maths programmes. Refer to Appendices J and K for the interviews used in this current study. The data coming from these interviews were thoroughly analysed and it was believed it would count very much in determining 'which' programme improved student performance in the experiment?

2.2.3 Classroom Observation

The teaching of the mathematics syllabus based on sets and occurring through 'Creative Maths' and 'Maths the Easy Way' was observed using 'on-the-spot' observation as claimed by Scriven (1967: 5). The aim was to compare these two training programmes on the basis of their strength to improve student performance when small-group and whole-class teaching methods were employed. Each learning-teaching environment would be described on the basis of what it does with reference to improving performance, in Maths basic sets theory, taught through small-groups and whole-class pedagogies. This observation of both methods of teaching was carried out to describe the learning environment and how learners interacted with one another as well as with their teachers in their respective groups assigned to them at the beginning of the experiment. Student performance would be the main focus in relation to how it is affected and influenced by these methods of teaching (small-group and whole-class).

These data-gathering methods formed important components of fieldwork to this study. They helped the investigator in interacting with the environment within which the experiment was set and conducted and within which the actual teaching of mathematics 'sets concepts and theory' occurred. Each method was arrived at collecting data considered relevant and suitable to address the overall proposed research problem mentioned in section 1.4 and to make available the kind of data that would enable the study to provide concrete answers to the research questions appearing in sub-sections 1.5.2 and 1.5.3 of this study. It is also important to mention that for both interviews and questionnaires various dates and times were arranged with the respondents first and in each case the purpose of the exercise was explained. Both interviews and questionnaires were conducted on a one-to-one basis and respondents were given time to think of what they were going to say. What they said served as important information to this current study.

In conclusion, it was believed that this research methodology section would succeed in recognising the fact that data and methodology were inextricably interdependent and for that reason, this research methodology was adopted in relation to this research project for a particular problem that logically must recognize and concur with the nature of the data that would be amassed in the resolution of that specific problem, namely, the *efficacy* of the two maths programmes in teaching basic sets theory. This *efficacy* was determined in the experiment using the two research questions, viz.:

2.2.3.1 On 'Which' Programme Do Students Perform Best in Mathematics: 'Creative Maths' or 'Maths the Easy Way'?

2.2.3.2 What Perceptions Are Held About 'Creative Maths' in Comparison With 'Maths the Easy Way' for Improving Students Performance?

These two research questions constituted the main focus of this study and each was tested as a hypothesis in the experiment. The Literature Review follows in Chapter 3.

CHAPTER 3

3. LITERATURE REVIEW

3.1 Introduction

The purpose of this review is to describe how small-groups can be of great use to teaching in the classroom compared with the whole-class method of teaching with regard to improving performance and participation.

The composition of the class undoubtedly influences both learning and teaching, but the amount and kind of influence depends both on the personality of the teacher and on his/her methods of teaching. For instance, a teacher who lectures from prepared notes and leaves no time for small group discussion will probably be minimally influenced by the class, whereas a teacher who plans work through discussion with the class will be greatly influenced. To add, a teacher who divides the class into smaller leaderless subgroups will find that what he/she can achieve will be crucially determined by the composition of the subgroups. Not ignoring what has been said above, it is argued that grouping varies in importance from one teaching situation to the next. It is inferred that the best group for one teacher may definitely not be the best group for another. This implies that successful grouping will have to be based partly on some kind of knowledge about each teacher for whom a class is composed. Brom-Bacher (1994: 10) who claims that some schools are experimenting with creative ways of handling large classes successfully quotes Human (1991) as saying that:

> Technically, the fundamental need for educational change in South Africa can be summarised as the need to provide more and more relevant effective educational opportunities, without consuming a much bigger slice of the gross national product than at present. This simply means that we have to deliver more educational goods (more pupils successfully and adequately provided with an education relevant to personal and societal needs), with the same educational means (money).

In Soweto most schools are hit by the problem of overcrowding in the classrooms. In an effort to deal with this ever-increasing problem of class sizes and the need to improve performance in the teaching of mathematics, the use of a small-group and big-group model was investigated, as advocated by Brom-Bacher (1994: 11). This model has three objectives, namely that student performance and participation should improve; that teacher productivity should improve; and that pupils should take greater responsibility for their learning.

3.2 The Small-Group and Big-Group Model

It is important to note that while this model is discussed in the context of teaching a subject (mathematics) to a whole standard, it can just as easily be applied to say two classes working together or even a single class with a single teacher. While one half of the students participate in a big-group, the other half of the pupils are divided among the remaining teachers in the team and are involved in supervised small-groups. One of the strengths of the big-group is that it creates small groups where more individualised support is possible.

With 'supervised small-group/unsupervised small-group', while one half of the standard (homogeneously grouped) participates in a supervised small-group, the other half (heterogeneously grouped) participates in an unsupervised small-group. The purpose of the big-group is for one teacher to introduce the students to the essential content of the topic (sets theory and concepts) being dealt with. The big-group is typically a workshop with students sitting in predetermined (heterogeneously grouped) groups. Instruction relies on the principles of co-operative learning and much use is made of unnumbered-heads together and working pairs. Co-operative learning involves students working together and being responsible both for their own and each other's learning. It is a valid approach to teaching and learning that addresses and caters for the most fundamental cognitive and social needs of the learner (Brom-Bacher, 1994: 10).

With 'unsupervised small-groups' students are organised in mixed ability groupings (of about six students) for unsupervised small-groups. The purpose of the unsupervised small-group is for students to work through topics helping each other, and in particular for the stronger students to help the weaker thereby ensuring that all finally gain a better understanding of the topic. It would not be usual for the group to be involved in some investigation or to be workshopping some activity. The module-teacher would be responsible for programming such an activity into the module. One important observation is that students are expected to have developed appropriate small-group interpersonal skills to be able to work effectively in unsupervised small-groups, as advocated by Brom-Bacher (1994: 11).

The following advantages of the model can be identified, according to Brom-Bacher (1994: 11). Refer to the **Table 4** given on the next page.

TABLE 4: TEACHER-STUDENT ADVANTAGES

Advantages for Teachers	Advantages for Students
Reduced number of topics to prepare.	Increased teacher-student and student-student interaction.
Increased quality of teaching/learning material.	Increased student performance and participation.
Teacher specialisation.	Increased responsibility for learning and understanding of the content studied.
Exposure to different teaching approaches and styles.	Exposure to different teachers and peer-groups.

Inherent in the model are a number of implications. At first some of these seem unsurmountable, yet with some lateral thinking they can be tackled. According to Brom-Bacher (1994: 11) the most significant implications are:

3.2.1 Timetabling: it is essential that all classes/groups in a particular standard and subject involved in the programme should meet at the same time for as many periods as possible.

3.2.2 Staff Allocation: the model implies that teachers be allocated so that more than one teacher teaches each standard.

3.2.3 Venues: at least one somewhat larger venue is needed to house the big-groups, and many small venues are required to house the unsupervised groups (consider converting old storerooms, etc.).

3.2.4 Teacher and Student Preparation: the model challenges many of the traditionally held notions about teaching and learning. Both teachers and students will have to spend time exploring some of these.

However, Brom-Bacher (1994: 11) believes that it is hard to quantify the effect of the model, though the underlying objectives can be achieved. This model contributes to the debate on large classes and has potential in terms of the provision of education in the years to come in

South Africa. Using the model it would be possible to teach large numbers of students using two 'expert' teachers and a team of 'apprentice/student' teachers. However, in my opinion this model could be useful in the experiment provided it was planned carefully with the aim of obtaining higher achievement and increased attention and participation from the students.

3.3 Exploration of Small-Group Instruction

Interest in the use of small-group instruction in American classrooms seems to be increasing (Brandt, 1989: 1; National Council of Teachers of Mathematics, 1989: 15; Slavin, 1987: 293). Small-group instruction is frequently advocated by educators (Canady and Hotchkiss, 1985: 344; Goodlad and Oakes, 1988: 16; Mathematics Framework for California Public Schools, 1985: 21) and recent research indicates that some small-group formats hold potential for improving secondary school mathematics achievement (Slavin, 1987: 293; Slavin, 1989: 129). However, despite considerable evidence that small-group instruction could facilitate acquisition of mathematical skills, there is little evidence that small-group teaching is uniquely helpful in facilitating higher order mathematical thinking or problem-solving skills.

Studies that describe the variety of small-group formats used by teachers and that identify effective small-group instructional processes are also practically non-existent. These shortcomings are noted by various theorists who have explored the potential of small-group instruction (Noddings, 1989: 607), by reviewers who have synthesized the research on grouping (Slavin, 1987: 296), and by critics who have pointed out the pitfalls of extrapolating from ability-grouping research (Garmoran, 1989: 341; Hiebert, 1987: 337). Recently several authors have called for comprehensive research on small-group methods (Good *et al.*, 1983: 56; Lindquist, 1989: 625).

Gerleman (1987: 3) provides naturalistic evidence about three forms of small-group teaching (i.e., two group, three group, individualized). After identifying teachers who used small-group teaching in the teaching of mathematics, her survey indicated that few did. Gerleman conducted her study on eleven fourth-grade teachers in three large urban districts.

Gerleman (1987: 4) finds that small-group instruction differs little from whole-class instruction (teachers taught two or three groups separately and in a traditional manner). She also notes that teachers used one or two general formats. In Type 1 grouping (2 of 11 classrooms), groups covered the same content separately (more advanced students often had an enrichment assignment while other students caught up). In Type 2 grouping (eight classrooms), each group

received different content and moved at its own pace. In the other classroom, a more flexible, individualized approach was used. Teachers in the Gerleman (1987: 5) study followed a basic instructional pattern in both Type 1 and Type 2 classes - presentation of the lesson followed by students doing practice work individually. She describes the small-group teaching as 'disappointing' since it exploits few of the advantages of whole-class teaching (for example, extended discussion of problems, a focus on conceptual understanding) or of small-group instruction (students learning more actively). In addition to a lack of emphasis on conceptual understanding and a tendency to use only textbook examples, both the time spent on development and the quality of development of mathematics concepts were less than desirable. Apparently because of a perceived need to 'manage' students, over 50% of the available time was used for review.

Gerleman also finds that small-group teaching does not allow academic interaction among students and furthermore, students rarely use higher cognitive processes (explaining solution methods; collecting data and making inferences). She concludes that the apparent purpose of grouping was to accommodate differences in student achievement - and not to introduce new content or to change the nature of mathematics instruction or the tasks assigned. Although her research describing some forms of small-group teaching could be a useful start, naturalistic research on other forms of small-group teaching is scant. To reiterate, there has been a paucity of observational studies that could be used to identify effective small-group teaching practices (Bossert, 1988: 115).

Research does exist on effective whole-class teaching, and instructional processes have been linked to certain student income measures-concepts and skills (Brophy and Good, 1986: 328; Grouws and Cooney, 1987: 69; Rosenshine and Stevens, 1986: 376). Experimental studies in mathematics demonstrate that 'active teaching' that focuses on meaningful presentation, along with higher expectations and reasonable accountability systems, is related to student achievement (Good *et al.*, 1983: 61). Development and direct instruction, in particular, are reported as important factors associated with student learning (Grouws and Cooney, 1987: 78; Rosenshine, 1979: 48; Rosenshine and Stevens, 1986: 376).

Research on time utilization has consistently showed relationships between instructional process and student outcomes. There are data to suggest that, when instructional time is used for academic purposes, and, when student engagement with appropriate tasks is high, successful

learning and improvement in student learning is likely to occur (Fisher 1978: 13; 1980: 87). However, such relationships are complex and depend on unit of analysis, context, etc. (Crawford, 1989: 37).

Studies of expert mathematics teachers reinforce the role of thorough explanations and demonstrations, teaching for understanding, and the efficient use of time and management routines (Leinhardt, 1988: 47). Furthermore, Leinhardt asserts that experts integrate various instructional moves or lesson segments - review, presentation, checking understanding, reteaching, applications and successful practice - into their lessons and create richer lesson agendas than novice or unqualified teachers.

Observational research that broadly describes the different forms of small-group teaching, that documents how teachers provide instruction within each form, and that discerns why some forms are more effective than others is instructive - especially given the current advocacy for small group instruction. There is also a need to explore how various small-group formats affect important factors in mathematics teaching (for example, the need for active teaching and active student participation/learning, an emphasis on conceptual understanding, variety in lesson presentation) that likely contribute to student outcomes. It seems likely that some organizational structures facilitate high quality instruction and learning experiences better than others.

Noddings (1985: 350), for example, is of the opinion that thoughtful, whole-class instruction can produce as much discussion and appropriate problem-solving as small-group instruction. Still, some forms of small-group teaching clearly have potential advantages - especially for certain types of social and mathematical learning. Lindquist (1989: 625) argues that use of small-groups in mathematics teaching and learning can encourage verbalization; increases students' responsibility for their own learning; encourages students to do work together (teamwork) to build social skills; enables teachers to individualize instruction and accommodates students' needs, interests and abilities; assists teachers in classroom management, and adds variety to the routine of mathematics classes.

The literature above suggests that it is important to evaluate, observe and describe the different forms of small-group teaching and teaching using these approaches, if we are to understand their strengths and limitations in relation to different goals of teaching. Hence, the current study's agenda was to compare and evaluate the teaching of mathematics in Soweto secondary schools using 'Creative Maths' and 'Maths the Easy Way' programmes. The aim was

to determine how various mathematical instructional moves or lesson segments impinge on student performance. On general terms it could be that small-group learning is as good as whole-class learning.

In this current study, mathematics teachers were expected to use either small-groups or whole-class teaching in the classroom. However, each one was expected to use the approach to its maximum and show great variation in its application. Although it could be argued that there are still many unanswered questions in educational research, many educational studies are making a claim that small group learning methods essentially demonstrated their effectiveness on a wide range of outcomes. For instance, they have proven to be practical and widely acceptable to teachers. Therefore, changing from a traditional competitive classroom to a co-operative one should not diminish student performance. Most often it improves it significantly. When co-operative learning methods are used in which small groups are rewarded on their effort of learning and learners are individually accountable for their academic performance, positive effects on achievement are consistently produced. Small-group teaching additionally improves the self-esteem and social outcomes of schooling such as intergroup relations, attitudes toward mainstreamed students and general positive relations between students. Efforts to improve the quality of teaching and learning in schools should be looked at seriously. Similarly low and poor performance in mathematics must be challenged. In this study the role of small-group and whole-class teaching methods would be looked at in relation to the extent they affect and improve student performance in mathematics.

This literature review will not be complete if themes that affect the teaching of mathematics are not discussed. These themes have their role to play in mathematics classrooms wherein young mathematicians are being labelled with all sorts of names to imply judgements about reasons why they do not perform as well in mathematics as might be hoped. For instance, as mathematics teachers we ought to avoid derogatory terms such as - 'less able children', 'slow learners', 'under-achievers' and 'low attainers' - especially when negative connotations are attached to them. Use of such terms in mathematics classrooms affect students negatively and psychologically and hence, their performance is also affected. We need to see learners being absorbed in their mathematical activities and being delighted with their experiences of understanding mathematical concepts and theory.

3.4 Themes Enhancing Performance

The following **themes** enhance student learning and performance in Mathematics:

3.4.1 Developing Understanding: Haylock (1991: 2) asserts that with low-attaining students in mathematics there must be a shifting of emphasis from the learning of routines and procedures towards the development of understanding. This is because of the problem that students are required to spend much time in mathematics lessons engaged in tasks which have no meaning whatsoever for them. These tasks provide them with no satisfaction or incentive for learning, particularly if their most frequent experience is of getting the answers wrong. Much of the satisfaction inherent in learning mathematics is that of understanding, that is, making connections, relating the symbols of mathematics to real situations, seeing how concepts fit together, and articulating the patterns and relationships which are fundamental to number systems and number operations.

3.4.2 Language: Haylock (1991: 3) claims that language development in teaching mathematics to low-attaining students is crucial because so often it is the case that poor language skills - reading, writing, speaking - are associated with low attainment in mathematics. Because mathematics has its own peculiar language patterns and vocabulary, a major part of the development of understanding of mathematics must focus on building up confidence in handling these and in connecting them with the corresponding mathematical symbols and manipulation of concrete materials.

3.4.3 Realistic and Relevant Objectives: Haylock (1992: 3) claims that it is particularly helpful when working with low-attainers to specify precise, short-term objectives for the learning of basic skills to be mastered in learning mathematics. This is done so that those students who have experienced repeated failure or poor achievement in the subject can recognise that they are actually making progress, however, such objectives must be realistic and relevant to the actual needs of the students taught.

3.4.4 Small-Group Games: Haylock (1992: 6) thinks that the use of small-group games and competitions is a way of enabling low-attaining students to practise and consolidate their mastery.

of basic number skills. Games and competitions are effective forms of purposeful activity, more interesting and motivating than simply ploughing through the pages of abstract sums in a textbook without ensuring the possibility of reaping the fruits.

3.4.5 Accuracy and Concentration: Haylock (1992: 36) sees this as an essential characteristic of school mathematics because success in the subject often requires care and accuracy. Students need to concentrate on their tasks and be self-disciplined in their approach to their work in mathematics. Lack of concentration and accuracy will inhibit and affect progress. Thus students must be provided with tasks designed specifically to develop their ability to see sequences and to develop their mathematical skills. It is only when the tasks are enriching, realistic and relevant that much progress will be made and performance increased in mathematics classrooms.

3.5 Conclusion

To conclude this section on the literature review, the background reading given above formed an essential contextual element of this piece of research. It is believed the review will inform this study and to make possible the evaluation of the two mathematics programmes compared, that is 'Creative Maths' and 'Maths the Easy Way'. It is also believed that it will help clarify the answers to the research questions tabled at the beginning of this research project. The results of this study are discussed in the next chapter.

CHAPTER 4

4. RESULTS OF THIS STUDY

4.1 Explanation

In this study 'the effect' of two ranking mathematics programmes was tested. This effect was determined by comparing the results of 'Creative Maths' with 'Maths the Easy Way'. This comparison was made more convenient by referring to the abovementioned programmes as **Treatment E and Treatment C** respectively. In determining the results for each of the abovementioned treatments a Pre-Test was first administered to 40 students before any treatment could be introduced. The test items were thereafter marked by both mathematics teachers according to correct and incorrect responses and marks allocated for each question. The total mark of correct answers was then expressed as a numerator over the total mark of all the test items put together as a denominator for each student in the sample. This fraction for each student was calculated and expressed as a percentage. Percentages were listed vertically according to two groups of 20 students each and students were paired by placement up to the twentieth pair. This Pre-Test was administered right at the beginning of the experiment before any teaching through the maths programmes could commence. This Pre-Test was referred to as Control (see **Table 4** overleaf) in the experiment because its main purpose was to serve as a measuring device and yardstick to which the performances of the groups resulting from other treatments (i.e., Post-Test 1 and 2), administered during the teaching-and-learning process, could be comparable. In other terms this Pre-Test was the standard, whereas the Post-Tests were a means of comparing the 'after effects' with the 'before effects'. Logically in this comparison there were variables referred to as 'independent' and 'dependent'. Our 'independent variable' in this instance was the pedagogy of teaching mathematics basic sets theory through small-groups and whole-class methods. It was from these pedagogies the understanding of sets by students would be established. The 'dependent variable' was the content of mathematics 'sets concepts and theory' taught to both the groups during the experiment.

As Tuckman (1978: 58) asserts, the independent variable is that factor which is measured, manipulated or selected by the investigator to determine its relationship to an observed phenomenon whereas the dependent variable is the factor observed and measured to determine the effect of the independent variable (Tuckman, 1978: 59). Furthermore, there were still other

factors involved, for example, 'control factors' (i.e., factors that are controlled by the investigator to cancel out or neutralise any effect they might otherwise have on the observed phenomenon), and 'intervening variables' (i.e., factors that theoretically affect the observed phenomenon but can neither be seen, manipulated nor measured and their effects are only inferred from the effects of other variables, for instance, the independent variable on the observed phenomenon) (Tuckman, 1978: 65 and 67). Indeed, the former were controlled in the actual experiment.

TABLE 5: THE TWO-GROUP CROSS-OVER DESIGN INVOLVING THE EXPERIMENTAL AND CONTROL GROUPS

Control (Pre-Test)	$RO_1 \times O_2$ = Pre-Test situation = No treatment given
1st Experiment (Post-Test 1)	$RO_3 \times O_4$ = Post-Test 1 Situation = End of Treatment 1
2nd Experiment (Post-Test 2)	$RO_5 \times O_6$ = Post-Test 2 Situation = End of treatment 2

There were altogether 40 students split into two groups of 20 students in Treatments C and E respectively. All 40 students wrote the Pre-Test and Post-Test 1 and 2. The Pre-Test was administered first, followed by the compilation of the Pre-Test results. Thereafter treatment one was introduced, and this took place through mathematics 'sets theory and concepts' being taught to participants through 'Creative Maths' and 'Maths the Easy Way' maths programmes. Subsequently Post-Test 1 was administered and the results were compiled based on student performance. A further treatment was introduced, followed by the administration and the compilation of Post-Test 2 results. This explains the procedure followed in administering the tests and intervals at which both treatments were given in the experiment. **Table 6** below illustrates a comparison of Pre-Test and Post-Test 1 and 2 percentages of students in their pairs.

A further step taken in the analysis of the results of this study was to 'pair' the students and to 'compare' their performances in these pairs according to Treatments C and E results of the paired groups. For example, students 1 and 21 formed a pair, and students 2 and 22 were another pair. In other words there were 20 pairs of students (i.e., the first pair up to the twentieth pair) altogether. **Table 6** illustrates the results of the experiment with respect to the Pre-Test and Post-Test 2 scores of participants in their pairs within their groups (i.e., Treatment C and Treatment E). At the bottom of this table a further analysis is given of the scores as obtained from the

TABLE 6: RESULTS OF THE EXPERIMENT UNDER TREATMENTS C AND E, ILLUSTRATING THE SCORES OF THE PRE-TEST AND POST-TEST 2

Student No.	Control		Student No.	Experiment	
	Treatment C			Treatment E	
	Pre-Test	Post-Test 2		Pre-Test	Post-Test 2
1	50.00	50.00	21	55.00	72.00
2	49.00	70.00	22	52.00	85.00
3	48.00	67.00	23	46.00	48.00
4	52.00	54.32	24	60.00	88.22
5	60.00	53.00	25	59.00	54.00
6	51.00	97.00	26	50.00	98.00
7	54.00	87.34	27	53.00	52.00
8	56.00	65.00	28	54.00	67.00
9	56.00	71.00	29	46.00	54.00
10	59.00	43.00	30	46.00	50.00
11	58.00	55.00	31	55.00	66.00
12	65.00	69.00	32	58.00	59.00
13	60.00	85.00	33	52.00	87.00
14	62.00	81.00	34	47.00	69.00
15	51.00	55.00	35	64.00	73.00
16	50.00	58.00	36	52.00	66.00
17	50.00	69.00	37	66.00	58.00
18	53.00	64.00	38	58.00	80.00
19	65.00	81.13	39	62.00	59.00
20	47.00	67.00	40	56.00	69.14
Mean	54.80	67.09		54.55	67.67
Std. Dev.	5.60	12.9		5.94	14.3
Min. Val.	47.00	43.00		46.00	48.00
Max. Val.	65.00	97.00		66.00	98.00
	Maths basic sets theory 5-8.			Maths basic sets theory 5-8	

TABLE 7: RESULTS OF THE EXPERIMENT UNDER TREATMENTS C AND E, ILLUSTRATING THE SCORES OF THE PRE-TEST AND POST-TEST 1

Student No.	Control		Student No.	Experiment	
	Treatment C			Treatment E	
	Pre-Test	Post-Test 1		Pre-Test	Post-Test 1
1	50.00	71.00	21	55.00	47.00
2	49.00	83.00	22	52.00	71.00
3	48.00	47.00	23	46.00	64.00
4	52.00	86.00	24	60.00	52.14
5	60.00	51.00	25	59.00	50.00
6	51.00	95.35	26	50.00	100.00
7	54.00	45.00	27	53.00	90.00
8	56.00	60.00	28	54.00	70.13
9	56.00	53.00	29	46.00	75.00
10	59.00	48.00	30	46.00	49.13
11	58.00	65.00	31	55.00	53.00
12	65.00	54.00	32	58.00	58.00
13	60.00	80.00	33	52.00	82.00
14	62.00	67.13	34	47.00	80.00
15	51.00	70.00	35	64.00	53.00
16	50.00	68.00	36	52.00	56.00
17	50.00	59.34	37	66.00	63.40
18	53.00	79.00	38	58.00	65.00
19	65.00	58.13	39	62.00	85.00
20	47.00	62.00	40	56.00	66.14
Mean	54.80	65.09		54.55	57.02
Std. Dev.	5.60	14.9		5.94	14.86
Min. Val.	47.00	45		46.00	47.00
Max. Val.	65.00	95.35		66.00	100.00
	Maths basic sets theory 1-4.			Maths basic sets theory 1-4	

individual result of each student in his/her pair. The results obtained were calculated in percentages. The students' individual percentages were then added up and the sub-totals divided by the total number of students in each group. So were the means, the standard deviations and the minimum and maximum values computed. For example **Table 6** indicates the means to be 54.80 and 67.09 for the Pre-Test and Post-Test 2 respectively for Treatment C (Control) and 54.55 and 67.67 for the Pre-Test and Post-Test 2 respectively for Treatment E (Experiment). The Standard deviations were calculated as 5.60 and 12.9 for the Pre-Test and Post-Test 2 respectively for Treatment C and, 5.94 and 14.3 for the Pre-Test and Post-Test 2 respectively for Treatment E. Treatments C and E above, represented the results/scores of students taught through 'Maths the Easy Way' and 'Creative Maths' respectively. The results of the Pre-Test and Post-Test 1 were also comparable within this framework of comparison as illustrated in **Table 7** above. The Post-Tests' order was not vital. There was no significant difference between 'Maths the Easy Way' and 'Creative Maths'.

In comparing the scores obtained by students in Post-Test 1 and 2 with those obtained by the same students in the Pre-Test, there was some degree of correlation even if it is not be very high. This is because this Post-Test were administered to participants *after treatment* and yet the Pre-Test was given to the same participants *before treatment* was introduced, hence the difference in performance of the mathematical items tested. The correlation referred to here was that relationship observable in performance through the scores obtained *before* and *after* treatment through the Pre-Test and Post-Test 1 and 2 respectively. In other words the three tests above showed three variables or things happening together but not at the same time. One (the Pre-Test) happens before the other (Post-Test 1 and 2). Similarly Post-Test 1 before Post-Test 2. This was an important observation.

Secondly there seemed to be a slight improvement in the scores obtained after the treatment periods through Post-Test 1 and 2. For example, considering student No. 1 (under Treatment C), his scores were 50%, 71% and 50% for the Pre-Test and Post-Test 1 and 2 respectively and hence student 21's score had improved from 55% to 72% (under Treatment E). Remember that student 1 and student 21 were paired. For counting now specifically about improvement in terms of the scores obtained above, student 21 performed better than student 1. Thus this observation alone could not permit us to conclude that 'Creative Maths' was a better programme for teaching maths compared with 'Maths the Easy Way'. The best approach would

have been to comment generally on the broad picture about the results rather than specific instances within this broad picture.

It follows that a broad picture concerning the results will be based on pages 38 and 39 illustrating **Tables 6** and **7** respectively and indicating student scores on mathematics basic sets theory of Post-Tests 2 and 1 respectively, each compared to the Pre-Test. Post-Test 1 scores were compiled from maths items based on maths basic sets theory 1 to 4 whereas Post-Test 2 covered maths items based on maths basic sets theory 5 to 8. The table columns are fairly simple and straightforward. In **Table 6** the mean averages were 54.80, 67.09 for the control group and 54.55 and 67.67 for the experiment group respectively in the Pre-Test and Post-Test 2. However in **Table 7** mean averages were given as 54.80 and 65.09 for the control group and 54.55 and 67.02 for the experiment group respectively. There was a very slight increase and improvement in both sets of mean averages. This increase or improvement was not at all great. Because it was very slight, it therefore indicated that the students' understanding of maths basic sets theory 1 to 4 and 5 to 8 was minimal. Though teaching did occur, there was a reasonable amount of quality understanding. As a result the difference in scores when the Pre-Test was compared with the Post-Test 1 and Post-Test 2 whether it be Treatment C or E, was not much.

In other words this difference was very slight and did not provide sufficient evidence of the efficacy of the teaching of 'maths basic sets theory and concepts' 1 to 8, using small-group and whole-class teaching methods in 'Creative Maths' and 'Maths the Easy Way'. The other observation was that there was no significant difference in student performance when using 'Creative Maths' and 'Maths the Easy Way' for teaching sets.

On the basis of these findings it was concluded that both maths programmes, i.e., 'Creative Maths' and 'Maths the Easy Way' had almost equal strengths for teaching students to understand 'basic sets theory and concepts' in mathematics. However with more time allowed to experiment with these maths programmes mentioned above, or for argument sake other maths programmes, there could be some significant difference. In conclusion, each of these maths programmes had a significant role to play in the experiment. **Table 8** below deals with the normality of the test scores distributed and an explanation to that effect is given below it.

The statistics in **Table 8** simply explain that the test scores were not normally distributed and thus, statistical tests based on the assumptions of normality were not likely to be valid. Most

TABLE 8: NORMAL DISTRIBUTION OF THE TEST SCORES

Test	Treatment	W: Normal	Prob < W
Pre-Test	C	0.9292	0.1575
Post-Test 1		0.9607	0.5621
Pre-Test	E	0.9580	0.5116
Post-Test		0.9481	0.3516

probably this situation resulted from the sample of the study not being large enough to allow that to happen. Testing was based on non-parametric techniques. These were used because there were doubts about the appropriateness of assuming normal distribution.

The tests were carried out as indicated below:

4.2 Test of Effect of the Treatments

This involved paired-tests between the scores obtained before and after the 1st and 2nd treatment periods. After taking the differences between various pairs a one-sample sign test was applied in each case. That is, if x denoted the number of scores above the median score then the test of significant effect was based on:

$$Z_{obs} = \frac{X - 20p_o}{20p_o(1 - p_o)}$$

with $p_o = 0.5$, which has approximately the standard normal distribution. Values of $| Z_{obs} | \leq 1.65$ and $| Z_{obs} | \geq 1.28$ indicated significant effects at **5% level** and **10% level** respectively. The significant effects imply that 'Maths the Easy Way' was effective at **5% level** compared with **10% level** of 'Creative Maths'. However the difference between the two ratings was not significantly high. Neither was it abnormally low. It was just right, indicating the more-or-less equal strengths of both programmes. The latter was slightly more effective in the teaching of sets than the former.

4.3 Test of Difference Between Treatments

This involved a non-parametric (Wilcoxon or Mann-Whitney) test of difference between the two group test scores obtained after training. By assuming that there was no difference between the two methods, we calculated the means and the standards of the combined test scores as:

$$\mu_{U1} = \frac{n_1 n_2}{2} \qquad \sigma_{U1} = \frac{n_1 n_2 (n_1 + n_2 + 1)}{12}$$

when $n_1 = 20$ and $n_2 = 20$ were the sample sizes in both groups wherein

$$U_1 = W_1 - n_1 \frac{(n_1 + 1)}{2}$$

and W_1 was the sum of the ranks of the scores from the first group when the scores in the combined group were arranged in order of magnitude. Thus we based the test on the null hypothesis that the two teaching methods were identical on the statistics:

$$Z_{obs} = \frac{U_1 - \mu_{U1}}{\sigma_{U1}}$$

which had approximately the standard normal distribution. Values of $| Z_{obs} | \geq 1.96$ and $| Z_{obs} | \geq 1.96$ and $Z_{obs} | \geq 1.65$ indicated significant effects at **5% level** and **10% level** respectively. The results here were similar to those in sub-section 4.2 above. 'Maths the Easy Way' was effective at **5% level** whereas 'Creative Maths' was effective at **10% level**. This significant difference was neither very high nor very low. It was just moderate or reasonable indicating more-or-less the same ratings and strengths of these maths programmes. The latter programme had a slightly higher percentage than the former, thus it was slightly more effective.

From this discussion it would seem that the results indicated that the effect for Treatments C and E were 1.34 and 1.79 respectively and their difference was -0.45 and +0.45 for Treatments C and E respectively. The direction of this difference was that Treatment C was less than Treatment E (or vice versa). The effect of Treatment E, was not great in comparison with Treatment C. Similarly the direction of difference was very small. This observation implied that the effects of the treatment were not great. See **Table 9** below for this comparison

TABLE 9: THE EFFECT OF TREATMENTS C AND E

$\| Z_{obs} \|$	Effect		Difference		Direction of Difference
	Treatment C	Treatment E	Treatment C	Treatment E	
	1.34	1.79	-0.45	+0.45	C < E

From this **Table 9** and the discussion accompanying it, Treatment C ('Maths the Easy Way') was statistically significant at **5% level** whereas Treatment E ('Creative Maths') was significantly effective at **10% level**. This implied that 'Maths the Easy Way' maths programme was effective at **5% level** statistically while 'Creative Maths' was statistically effective at **10% level**. Therefore, it was concluded that neither 'Creative Maths' nor 'Maths the Easy Way' was best in improving student performance when compared. Instead both maths programmes indicated the same quality and strength in the teaching of sets. However it was felt that if there was more time granted to this study, results would have been better or different. Unfortunately this was not possible due to time constraints impacting on this study. Furthermore the **levels of 5% and 10%** of 'Maths the Easy Way' and 'Creative Maths' were not very significant and the difference in them was not so great to the extent that we could say 'Creative Maths' or 'Maths the East Way' was a maths programme on which students preformed best. Therefore the speculation made before the experiment, was not true because the statistical difference between **5%** and **10% levels** was so little that we could not argue that on the former programme students preformed best. In other words, there was insufficient statistical evidence to demonstrate that **in fact** 'Creative Maths' programme was the best. These programmes proved to be almost of equal strength and quality. Similarly it was concluded that the small-groups teaching in 'Creative Maths' was slightly more successful and effective in improving student performance than 'Maths the Easy Way'.

CHAPTER 5

5. DESCRIPTIVE DATA

These data were gathered through **observation** of group classes taught through 'Creative Maths' and 'Maths the Easy Way', **questionnaires**, administered to participating students and to teachers who taught mathematics 'sets concept and theory' through 'Creative Maths' and 'Maths the Easy Way', and through **interviews**, conducted with teachers and DET officials. The data were useful in addressing the second research question, namely: What perceptions are held about 'Creative Maths' in comparison with 'Maths the Easy Way' for improving student performance? These data were used in providing multiple perspectives of the alternative teaching methods considered in this comparative study from the point of view of pedagogy based on Mathematics 'sets and concepts and theory' through the two mathematics programmes mentioned in this study and from the point of view of people in and outside the sample of the study including mathematics students, teachers, and DET officials.

5.1 Observation of Group Classes

The two groups, namely the **experimental** 'Creative Maths' and **control** 'Maths the Easy Way', participating in the current study were observed during the teaching-and-learning of mathematics 'sets concepts and theory'. These observations were made by the researcher from day one up to the last day of teaching. The purpose was to gather data that would enable the learning milieu to be described in its natural state. Parlett and Hamilton (1972: 90) describe this milieu as the social-psychological and material environment in which students and teachers interact and work together co-operatively. The learning milieu represents a network or nexus of cultural, social, institutional and psychological variables. It is these variables that interact in complicated ways to produce in each class or course, a unique pattern of circumstances, pressures, customs, opinions and work styles which suffused the teaching and learning that occurred there. Very particular aspects observed in the teaching of mathematics 'sets concepts and theory' were recorded and will be discussed in this section. It is because they intrigued the entire teaching-learning environment and excited what was to be observed.

I, the researcher, attended a total of twelve sessions for each mathematics teacher during normal teaching and treatment periods. It must be noted that my presence in the lessons of

'Creative Maths' and 'Maths the Easy Way' was keenly felt and students looked at me as a school inspector and the majority of them in both sessions thought my function was to examine the teaching in schools. To an extent they would be correct if that role was to be related to the conducted experiment. In most cases I would sit at the back or be centred in 'Maths the Easy Way' sessions, listen attentively, observing and taking notes on the teaching as a whole, noting aspects and dynamics including reactions involved of both students and the teacher as lessons unfolded. I was also interested in the language used mathematically in those sessions, how students expressed themselves in relation to questions asked and how relevant they were in solving problems and suggesting ideas that led to that. Certainly, I would not walk about or around the classroom whilst teaching was in progress. When students needed help, it was for the teacher to walk around giving assistance to students who needed it and just making sure that there was progression and continuity and that there was discipline and conditions were conducive for learning.

In 'Creative Maths' I would move from one group of students to another since small-group teaching allowed and encouraged that kind of behaviour, particularly when the teacher, as a facilitator, has to guide and advise learners as part of facilitating what they are expected to learn, namely mathematics basic sets theory and concepts, by ensuring that they understand the concepts and can apply them practically using all sorts of skills demanded by the application of such concepts. I was fascinated by the manner in which, and the levels at which, students in those small-groups could learn. It was important and necessary for me to really move around noting and observing the sort of small-group dynamics that were created from the energy of learning that flowed out of student participation in those sessions.

In both programmes there was evidence of high academic interaction among students themselves and between students and their teachers. In both sessions students used higher cognitive processes - explaining solution methods, relating such processes to action, collecting mathematical data, making inferences etc. Each teaching method was handled appropriately by the teacher concerned. All sessions were dominated by discussions in both sessions of the two mathematics programmes. Indeed one could see the differences between the methods of teaching in the way they were applied in teaching the groups, and one could realise how important it was to evaluate, observe and perhaps describe the different forms of small-group and whole-class teaching in relation to the teaching of mathematics (using these approaches). The strengths and

limitations of these methods discussed here ought to be understood in terms of the different goals of teaching.

The procedures in each class were generally similar. Each mathematics teacher would explain a concept, usually write it on the chalkboard, present a series of questions on the concept and expect responses from students on the concept discussed. The teacher in charge of 'Creative Maths' had a range of practical skills that enabled him to carry out what he decided to teach; skills that enabled him to produce materials and activities, including displays and learner aids that enhanced his teaching, unlike the 'Maths the Easy Way' teacher who lacked the ability to do that.

In the teaching sessions of both 'Creative Maths' and 'Maths the Easy way' students were expected to acquire knowledge and certain cognitive and behavioural skills during the instructional periods. They were expected to work on the content, presented in various ways with the help of various media and equipment, ranging from very concrete to symbolic and highly abstract forms. Students were further required to carry out activities which challenged their reasoning capacities through operational ways and through problem-solving strategies. They were also encouraged to discover procedures that would produce answers on the content they were engaged in through word problems. Concerning problem-solving Simon and Simon (1978: 413) are of the opinion that better problem solvers use powerful, content-related processes and they further claim that students enjoy being problem-solvers by tending to work forward, beginning with a qualitative, step-by-step approach in which specific data are 'plunged into' formulae or answer-giving rules.

In conclusion a definite comparison on 'which' programme was perceived to be better for improving student performance in mathematics basic sets theory had to be made hereunder. It was particularly apparent to the observer that in 'Maths the Easy Way' more than half (i.e., 12 students ≈ 60%) out of 20 students in the group were struggling in dealing with the day-to-day work on sets, however, it was important and interesting to note that they were all enjoying sets and very eager to learn. I also think that this attitude was a more positive one made possible by their teacher's approach and ability to teach them. As a result their confidence was increased with each new section of the content, however, in 'Creative Maths' each new section was handled well and students participated actively and seemed to know, like, and understand what they were doing on sets. Small-group dynamics ensured that each learner focussed on the work and that they could all be accountable for their own learning and strugglers were quickly assisted. From my own observation, to record, there were two students in that group (i.e., two students ≈ 10%) of 20

students who really needed individual attention continuously as each lesson unfolded. These figures meant more students needed help in the former than in the latter mathematics programme. Another set of evidence indicated that learning was smooth in terms of the flow of lessons, discipline and co-operation in the learning environment, particularly in 'Creative Maths' when compared with 'Maths the Easy Way'. This evidence compelled us to conclude that teaching sessions in the former class were more organised than in the latter class. Thus, on the basis of the observation of the group classes during teaching and learning processes, it was concluded that 'Creative Maths' was perceived by students and teachers involved in the learning transaction as a better programme for improving student performance in comparison with 'Maths the Easy Way'.

5.2 Questionnaires

These served as further sources of data providing evidence on what perceptions students and teachers had of 'Creative Maths' in comparison with 'Maths the Easy Way' for improving student performance in teaching 'sets concepts and theory'. Students and teachers each completed separate questionnaires because they were not at the same level in mathematics and their experiences in the subject differed immensely. The results are discussed below.

5.2.1 Student Questionnaire (Appendix H)

Generally students were more positive than negative about 'Creative Maths' than 'Maths the Easy Way'. The majority of students, i.e., 90% of students in 'Creative Maths', felt very content with this programme, how mathematics 'sets concepts and theory' was taught through it and its potential to improve student performance. They rated themselves at 4s saying they all agreed. About 7% of the students felt that more teaching and explanation time should be given in the classroom, and they rated this at rating 3 whereas only 3% could not comment with accuracy and clarity on the programme. In 'Maths the Easy Way' students were not as clear as those of the other group in responding to the questions in the questionnaire. The percentage of positive responses was 55% (rating 4). About 28% of the students in this programme wanted more time to be allocated to teaching and only 17% claimed the programme was not helping them much, with ratings of 3 and 2 respectively. The student questionnaire had four sections to which respondents had to respond. The results are summarised in **Table 10** below, indicating how they responded:

TABLE 10: STUDENT RESPONSES TO THE QUESTIONNAIRE

CREATIVE MATHS	MATHS THE EASY WAY
I. The Course Itself	
Students enjoyed all the aspects mentioned in the questionnaire under this heading. The outcome was judged as 90% of students agreeing strongly that they liked the course, that it was too hard and challenging with good learning methods that changed their attitudes about mathematics combined with sufficient homework and very clear assignments and follow-ups (rating 5).	Students were divided on various aspects. The outcome was that 55% found the course relevant with good methods for learning combined with sufficient homework assignments that could change their attitudes about mathematics. However, 35% of students indicated very poor methods being used, with unclear assignments and the course not doing much in changing their attitude (rating 2).
II. You as Student	
90% of the students in this programme agreed strongly that they were well-prepared for lessons, showed interest in learning, asked for help when needed, put best effort into homework activities and learned a lot out of the programme. Only 10% claimed they showed interest though they were poorly prepared and did not make it fun for the teacher as they were confused at times and as a result putting very little effort and avoiding to ask questions. They were blaming themselves for having missed out on other areas of the programme (ratings 5 and 1).	55% of the students strongly agreed that they participated actively by being well-prepared for sessions and showing interest though not enough time was available to ask questions as the teacher was at times shouting. 28% of students felt they needed help but could not ask for it as they were not following what was taught and were at times very confused by the teaching methods. They also indicated that should they be given another chance in this group they would improve (ratings 4 and 2). Note that categories in column II are not necessarily the same because the information was recorded as pure as it was given by the students concerned.

CREATIVE MATHS	MATHS THE EASY WAY
III. The Teacher	
100% of the students agreed strongly that the teacher was well-prepared, interesting, fair but caring and presented enough variety, offering help to his students. Generally students in this group enjoyed being taught in this way (rating 5).	Only 58% (rating 3) of the students agreed strongly on the overall preparedness of the teacher with some reservations on his strictness and failure to be approachable. 40% (rating 2) found their teacher interesting, fair and able to provide assistance. Only 2% (rating 1) were not sure.
IV. Methods	
80% of the students liked the cumulative method of homework and saw the value of it in learning. They also found it self-fulfilling to study for mathematics tests. Only 20% disagreed but planned to take more mathematics in school than they would have normally (ratings 4 and 1).	About 55% of the students liked the cumulative homework and thus did not see its value. About 28% claimed the methods of teaching were relevant and interesting, whereas only 17% did not find it easy to prepare for tests (ratings 1, 3 and 2).

Comparing the two programmes - 'Creative Maths' and 'Maths the Easy Way' - on the basis of percentages given to how the students responded to questions in each of the four subsections of the questionnaire, it was concluded that 'Creative Maths' had a high potential for improving student performance when compared with 'Maths the Easy Way'. It was important to note that the 'Creative Maths' group was positive and had higher ratings of 4s and 5s compared with 'Maths the Easy Way' ratings of 2s and 3s. However, these ratings above and percentages in **Table 10** signified information about how the two mathematics programmes were perceived and despite this evidence not being supported statistically. The majority of students perceived 'Creative Maths' as the programme with potential for improving student performance in comparison with 'Maths the Easy Way'.

5.2.2 Teacher Questionnaire (Appendix I)

This questionnaire had 20 items to which mathematics teachers teaching the programmes responded individually. The data showed that there was great commitment to teaching in general and teaching goals and objectives were taken very seriously in the light of teaching mathematics 'sets concepts and theory' through 'Creative Maths' than 'Maths the Easy Way'. Teaching methods in these programmes were relevant and appropriately used. The 'Creative Maths' teacher had his ratings as follows: **12 S's** on items **1, 2, 3, 4, 5, 6, 7, 8, 9, 13, 17** and **18**; **3 M's** on items **14, 15** and **16**; and **5 N's** on **10, 11, 12, 19** and **20**. The ratings of 'Maths the Easy Way' teacher were given as: **9 S's** on items **1, 2, 4, 5, 6, 7, 8, 9** and **11**; **4 M's** on items **14, 15, 16** and **17**; and **7 N's** on items **3, 10, 12, 13, 18, 19** and **20**. Each teacher's ratings were multiplied either by **5, 3** or **1** and the totals for each teacher were calculated as follows: For example, the 'Creative Maths' teacher had **(12 x 5) + (3 x 3) + (5 x 1) = 60 + 9 + 5 = 74** points whereas the 'Maths the Easy Way' teacher had **(9 x 5) + (4 x 3) + (7 + 1) = 45 + 12 + 7 = 64** points altogether. These scores or points were also comparable in terms of the two mathematics programmes and the ability of the teachers in relation to the items listed on the questionnaire (Appendix I). The 'Creative Maths' teacher had a higher rating than the 'Maths the Easy Way' teacher. The researcher had a meeting with both teachers in order to discuss their situation. I (the researcher) went further to show them sheets on which they were rated by me. Each teacher had an opportunity of comparing his ratings done by me with those done by him. It was important to observe that I had rated the 'Creative Maths' teacher in the 70's and scored the 'Maths the Easy Way' teacher 60 points. The former was still higher on points in comparison with the latter. This meeting was very fruitful and enlightening in terms of discussing generally about mathematics and how well it should be taught in the classroom. Both teachers agreed that each had to improve on a number of skills and that this had to be seen as a process. They both realized how important it was to be skilful, particularly in mathematics and the idea of improving performance was well received. More positive comments were directed to this programme than its rival. Both teachers agreed, however, that there were areas that needed attention as a means of, or way forward for, improving them. Following the questionnaires, these areas were recorded as points **6, 9, 12, 16, 17** and **18**. These areas were discussed in a separate meeting with the teachers concerned as a matter of urgency for feedback and empowerment purposes because basically they would still continue to teach mathematics at the school where this study was conducted. These data revealed that 'Creative

Maths' was viewed as the programme that had potential to improve student performance and on which mathematics students performed best in comparison with 'Maths the Easy Way'.

5.3 Interviews

These interviews were conducted to gather further information related to perceptions of the two mathematics programmes, namely 'Creative Maths' and 'Maths the Easy Way' in so far as improving performance was concerned. Interviewees were consulted at the work place and interviewed on a one-to-one basis. These interviews involved mathematics teachers and DET officials. The former were interviewed first and the latter were the last to be interviewed, all at different times on different days.

5.3.1 Mathematics Teachers Interviews (Appendix J)

Both teachers responsible for 'Creative Maths' and 'Maths the Easy Way' thought that the investigation mode was an important part of mathematics teaching. The 'Creative Maths' teacher said that this mode presented the students with an opportunity to explore the ideas presented, often with minimum teacher direction. Sometimes this exploration consisted of an investigation with concrete objects and at other times, the student simply used paper and pencil to explore ideas with number. Mathematics sections should have been more child-centred because this would have enabled the children to explore new ideas, or known ideas in a new way. This was self-exploration through which a great deal could be learned by students in mathematics classrooms. For instance, students that were taught in the experiment benefited from discussing investigations in their small groups. They were directed to read through the investigation section and to figure out which cards were Eric's set (according to the activity). It also took some children quite a bit of discussion to realize that the only acceptable objects were those on which a circular shape appeared. Indeed, exploration demanded that teachers should encourage creative thinking as they moved around the classroom and avoid giving answers to children's questions too quickly. Rather stimulate thought with questions of your own, such as:

"What is similar about the objects in the first set? In the second set?"

"Would a waste paper basket be in Eric's set?" (an activity done in the classroom).

In this way the investigation mode could be important.

The 'Maths the Easy Way' teacher said that the investigation mode was important because it helped the students to identify the common arithmetic property shared by all the numbers in a given illustration. For example, most students may not have had any difficulty recognizing the multiples of 5 and representing them in a set. This teacher further used the following example to illustrate his point:

"All of these are in the set": 49, 21, 35, 91, 364, 140.

"None of these is in the set": 10, 24, 12, 100, 81, 71.

He also mentioned that children could further be asked to list more members in both sets above. This would help the children to build up an intuitive notion of set, at the same time they were activities that should be treated as enjoyable mental activities rather than as rigorous problems. His other viewpoints were that in investigations children should be encouraged to work independently and be directed to study patterns and try to figure out how each number is formed in relation to the number preceding it using corresponding dot patterns, for example:

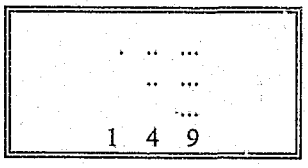


Figure 2: Dot Patterns

This teacher felt that to explore and to investigate in mathematics was important because students were encouraged and motivated to discover things by themselves, independently.

Responding to the question "Is discussion in teaching mathematics vital?", the 'Creative Maths' teacher said that discussions in mathematics provide an opportunity for students to discuss the ideas they investigated and for the teacher to guide the discussion intelligently and constructively so that the emphasis was on the main point of the lesson. In such discussions a teacher may want to demonstrate various computational skills or use visual materials to highlight a particular concept taught. He also said that questions should form part of discussions as they help students to focus on the most important concepts, skills in guiding the discussion and presenting ideas would be of value in teaching. The discussion is vital.

The 'Maths the Easy Way' teacher thought that discussions gave students an opportunity to talk more and freely about what was investigated or the kind of skills and techniques taught. He stressed that every investigation section in mathematics must be followed by a discussion session although this might not always be the case. This was because discussions developed the reasoning powers and critical thinking. He said if logic was developed in a student then the chances that he/she be rational were great and generally the moment you wanted to start teaching, you opened your mouth having thought carefully about what you were going to say. The moment you said it you were talking, and talking involved discussion. This teacher concluded by saying teaching was another form of discussion and that discussion was equally as important as teaching in the mathematics classroom.

Question three read "Have you enjoyed being part of this experiment? Explain." The 'Creative Maths' teacher responded by saying that this opportunity (being part of the study) was a learning experience for him. He said that the mathematics programme provided the necessary mastery of basic number skills crucially needed by students, and that it presented the material in a way that emphasized the exciting, creative nature of mathematics. He also realized that as his students became involved in exciting explorations and investigations, the structure and beauty of mathematics unfolded to the benefit of those taught. The programme helped students to be motivated and eager to investigate and discover for themselves, to look for interesting patterns and relationships, and to develop their own generalizations.

In response to the question above the 'Maths the Easy Way' teacher said that it was a wonderful experience to share together with his group. A lot could be learned from each other and about each other as individuals. He said that although his programme was using a whole-class approach in the teaching of mathematics 'sets concepts and theory', the experience was worth it. This was because the entire class worked together on the same lesson but individuals were allowed to proceed, reason and think at their own speed. The programme allowed active student participation. Once a topic to be learned was introduced, it was explored in great detail, the main purpose was to develop and pursue it until a desired level of understanding with regard to that topic was reached. He said that his group was a mixed ability group and in compiling worksheets for them he had to take into consideration the needs, abilities, interests and time available for each individual student. For example, if the teaching time was short he had to move rapidly through a particular lesson or the teaching of a specific concept, and the assignment given as part of the

application would be the minimum for all students. He said he was fascinated by situations in the classroom wherein the more able students would take control of the class and learning and demonstrate their ability to perform particular skills with great efficiency. This learning experience was shared by all in the learning environment. He concluded by saying he would do it again if so requested.

The final question "What do you think of the two mathematics training programmes used in the experiment? Elaborate", was responded to by both teachers. The 'Creative Maths' teacher indicated that indeed his training programme would not have been so very successful without the use of small-group teaching. He said that the programme achieved success owing to the co-operation and determination of his students which contributed to his classroom organization. Each small-group worked as a team on the same lesson. Although at times groups would be varied this did not pose a problem. In fact it was very stimulating to vary the sizes for different lessons and units of work, also judged on activities to be done. In all cases smaller-size groups often worked more effectively together and allowed greater opportunity to participate in activities that called for investigation and discussion based on self-discovery. This classroom learning set-up produced active student participation and it was the strong point that contributed to the overall success of 'Creative Maths'. All this was said by the 'Creative Maths' teacher.

The 'Maths the Easy Way' teacher responded by saying that some students in his programme showed lack of focus, determination, motivation and interest. A few were not as co-operative as they should be. The area of sets was definitely the introduction of a new concept of mathematics and this needed their full attention and maximum co-operation. The exercises were set in such a way that they were graded, beginning with the easiest ones and ending with the more challenging. For example, from time to time there would be a fairly easy challenging problem provided to encourage the less able students to attempt it. Most of the students, according to this teacher, were slower students who would take more time to complete the work given to them. The more able students were perfectly in control of their own learning and needed very little guidance. He also indicated that teaching time was hindered by groups of students who needed more guidance and attention. Despite this, he felt that generally [illegible]ent well but not as well as he had expected and he had a strong feeling that [illegible]ourse should be extended as a great deal had to be done apart from teaching.

In conclusion, views given by both teachers had to be compared and judged, taking into account what they said about 'Creative Maths' and 'Maths the Easy Way'. What came out from these interviews were general elaborations based on interview questions by the 'Creative Maths' teacher and 'Maths the Easy Way' teacher. There was no clear concrete evidence given on the question, viz., 'Which' programme improved student performance? There were however specific instances where both teachers felt that the mathematics programmes were valuable to the students and to them as mathematics teachers. They felt that students benefited from them both.

5.3.2 DET Officials Interviews (Appendix K)

Two senior officials named A and B were interviewed on different days in the DET offices, Braamfontein. The first question posed was "Is evaluation of student progress necessary in a mathematics classroom?".

A responded: Any evaluation on work done by students was necessary, whether formal or informal. For example, observation of students' responses on work taught and learned in a mathematics classroom should indicate which students needed particular help in building a positive attitude both towards the study of mathematics and towards themselves as learners. All too often, evaluation procedures focussed attention on what the child did not understand or master, rather than on what the child did accomplish. In evaluating a student's progress, a positive view, one that capitalized on success and developed confidence must be maintained. To add to that, you may find that a day-to-day evaluation of the students, often involving interviews, would help the teacher to determine how well a child grasped the concepts and how well he was able to apply them.

B responded: Evaluation helped to identify students who demonstrated a highly developed ability to reason and think logically from those who were less able to or could not. It also helped the teacher to know if learning outcomes, performance objectives for these outcomes and progress based on these outcomes were attained. Without evaluation progress could not be measurable.

The second question "Are mathematics students exhibiting any attitudes as they learn in the classroom?", was responded to as follows: Official A said that there were many different attitudes exhibited by students who had been exposed to classroom mathematical experience. There were, of course, the more general attitudes that a student had towards his teacher, towards his subject, towards his school, towards his fellow students, and towards the process of education.

Official **B** responded by saying that many different attitudes were being exhibited by students in the learning-teaching environment, but in my own opinion the two most important attitudes were the student's attitude towards mathematics and the student's attitude towards him- or herself. It has been said that the mathematical experiences of a student before the age of eleven, and the responses he/she has been encouraged to make to those experiences largely determine his/her potential mathematical development. Official **B** finally said that if this was so, then a student's attitude towards mathematics and his/her feelings about how he/she related to mathematics were extremely important considerations for the classroom teacher.

Question three was, "Is investigation and discussion important in mathematics? Explain.". Official **A** said that both investigations and discussions stimulated teaching as teaching strategies. They were both central to the learning experience. For example, through investigations and discussions students were made, and encouraged, to become actively involved in a lesson, either individually or in groups, investigations of situations that contained the seeds for the central idea of the lesson and discussing their investigations as they went along. Official **B** said that investigations were specifically designed to encourage students to take responsibility for thinking and exploring, and discussions were a means to facilitate this, for example, larger-group discussions occurred after the investigations. Discussions, according to this official, allowed both the teacher and the students to share further 'ideas' in a discussion of what they found in the investigation.

The last question was, "What are the kinds of things students learn in mathematics to improve performance?". Official **A** commented that the types of things students learn are concepts, skills, generalizations, facts and attitudes. For example, the teaching and development of concepts and generalizations provided a child with a feeling of power regarding mathematics, for when he/she experienced the thrill of discovering a concept or a generalization, or when he/she used these to solve problems, he/she was also developing a useful and wholesome attitude towards mathematics learning and his/her performance was extensively improved. Official **B** responded by saying that skills and facts in mathematics ought to be more emphasized because they provided the student with the basic sense of security accomplished simply from being able to do something or to remember something. This security would increase the confidence needed by the student to experience success. As a result the student's performance was increased. Learning was enhanced.

In conclusion, suggestions by these senior officials described what students should do or normally not do in mathematics education in order to achieve success, and how teachers should help students to accomplish this goal. Most teaching, according to them, should be directed towards improving student performance. What should be noted here was the fact that what each official commented on did not directly relate to the first research question, namely: On 'which' programme do students perform best in mathematics: 'Creative Maths' or 'Maths the Easy Way'? Issues or matters related to this subject were supposed to take precedence over any other matters concerned with the teaching of sets in the experiment of this study. This study was prepared to deal with such situations. A concluding chapter overleaf summarises critical comments on 'Creative Maths' and 'Maths the Easy Way'.

CHAPTER 6

6. CONCLUDING COMMENTS ABOUT THE MATHEMATICS PROGRAMMES

6.1 Introduction

This section serves as a concluding chapter of this study. Its main purpose is to comment critically on the two mathematics programmes used in the experiment in relation to the two main research questions proposed as hypotheses tested in this study. For the purpose of this discussion, they are re-stated:

6.1.1 On 'Which' Programme Do Students Perform Best in Mathematics: 'Creative Maths' or 'Maths the Easy Way'?

6.1.2 What Perceptions Are Held About 'Creative Maths' in Comparison With 'Maths the Easy Way' for Improving Student Performance?

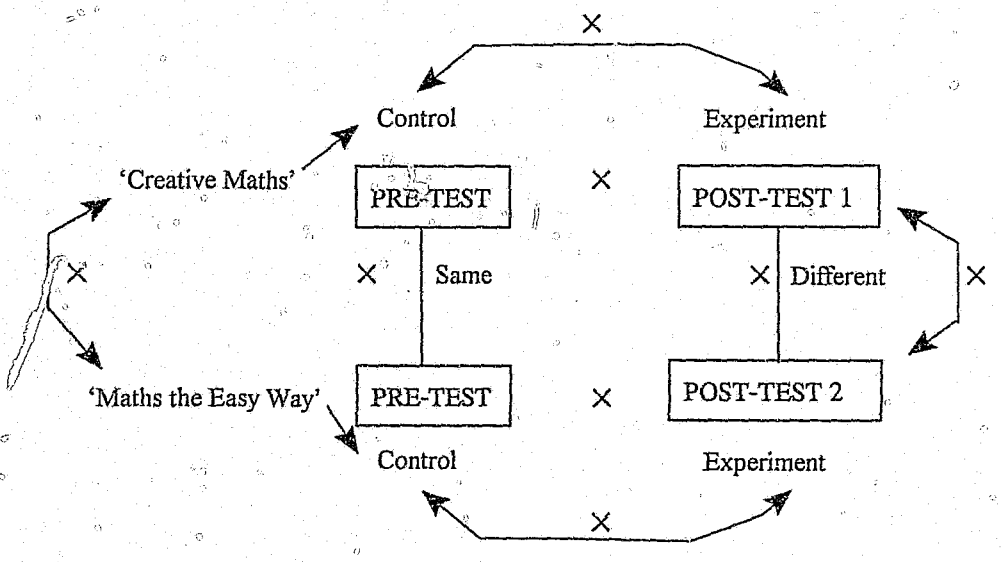
6.2 Comments on the Research Question: On 'Which' Programme Do Students Perform Best in Mathematics, 'Creative Maths' or 'Maths the Easy Way'?

The research question stated above constitutes only part of this study's backbone. It is one of the central questions that served to provide a vivid focus of the problem the study was interested in pursuing. As a hypothesis it had to be tested within the context of this study Statistical evidence gathered in the experimental design of this study indicated clearly that both programmes, 'Creative Maths' and 'Maths the Easy Way' were comparable and measurable in terms of the nature of student scores obtained through the Pre-Test, Post-Tests 1 and 2. These tests were selected and used in the experiment as important data-gathering devices. The scores obtained by individual students were categorized according to individual groups assigned to participants by being matched and randomized.

In this study these groups were recognized as **Control** and **Experiment**. Thus the significance of having such groups in an experimental design of this study was to make possible the feasibility of measuring and comparing student scores obtained by means of the Pre-Test and the two Post-Tests of this study. The measurement and comparison of student scores was based on two mathematics programmes, i.e., 'Creative Maths' and 'Maths the Easy Way', through which

students in their control group and experiment group were taught mathematics basic sets theory using small-group and whole-class methods of teaching respectively. One mathematics teacher was assigned to the control and experimental groups respectively.

A specific technique was carefully designed as a framework on which the matching and comparison of student scores was based. This technique involved recording student scores in terms of percentages and matching them cross-sectionally within the two mathematics programmes ('Creative Maths' and 'Maths the Easy Way') and cross-sectionally within the two groups of the experiment in the study, viz., the control and the experiment, before they could be compared as illustrated below:



× represents the magnitude and direction of this matching and comparison.

Figure 3: Schematic Representation of Comparing and Matching Student Scores

From Figure 3 above the matching and comparison of student scores occurred between 'Creative Maths' and 'Maths the Easy Way', between the Control and the Experiment, between the Pre-Test and Post-Test 1, between the Pre-Test and Post-Test 2, as well as between Post-Test 1 and Post-Test 2. It must be noted that in the experimental design of this study the Pre-Test was of the same nature and quality whereas Post-Test 1 and 2 were different and served different purposes, each test considered within its own context and meaning. These matchings and comparisons of the student scores referred to above were conducted and based specifically on the

sample of 40 students paired to one another from the first pair up to the twentieth pair, for example, student 1 was paired with student 21, student 2 with student 22 and so forth up to the twentieth pair. This pairing of students according to this framework is clearly illustrated in **Tables 6** and 7 on pages 38 and 39 respectively of this research report. Similarly next to each student the scores were given or recorded accordingly as scores of the Pre-Test, Post-Test 1 and Post-Test 2 in columns. The columns in each table were clearly marked Treatment C (i.e., Control) and Treatment E (i.e., Experiment). In this research report, the student scores of Post-Test 2 preceded those of Post-Test 1. It should not in any way imply that Post-Test 2 was administered first. In other words the order should not be a criterion and it is thus not important, however, it is the discussion based on these tests that is vital. No real names of students were used but instead numbers were given to each participant and this arrangement was done for convenience sake.

In **Table 6** the mean values of **54.80** and **67.09**, and, **54.55** and **67.67** were calculated according to the sum-total of individual scores in percentages as obtained by participants in their Control group or Experimental group under Treatment C or E respectively. The sum-totals were divided by the total number of students as represented within their pairs, i.e., of 20 participants. The same procedure was applied in **Table 7** in as far as the mean values were concerned. This being the case concerning the mean values, a further step was to focus on both **Tables 6** and 7. The differences of the mean values were calculated as follows:

TABLE 11: DIFFERENCES OF THE MEAN VALUES

Table 6	Control	Difference	Experiment	Difference
Means	67.09 - 54.80	**12.29**	67.67 - 54.55	**13.12**
Table 7	Control	Difference	Experiment	Difference
Means	65.09 - 54.80	**10.29**	67.02 - 54.55	**12.47**

The differences in the mean values were **12.29**, **13.12** and **10.29**, **12.47** respectively for **Tables 6** and 7. These differences were based on the tests themselves, viz., the Pre-Test, Post-Test 1 and 2. In both situations above Post-Test 1 and 2 scores are compared with those of the Pre-Test, under Treatment C and Treatment E. It was found that there were **small** differences in the mean values. The final differences in the mean values were calculated as follows:

Table 6: 13.12 - 12.29 = 0.83

Table 7: 12.47 - 10.19 = 2.18

Having to consider the values above, of **0.83** and **2.18**, these calculations proved further that the difference in performance was small when comparing the Pre-Test scores with those of the Post-Test 1 and Post-Test 2. The evidence given here supported further the statistical evidence discussed and provided on page 44 of this study. There was not any significant difference statistically between 'Creative Maths' and 'Maths the Easy Way' with regard to student performance or concerning the programmes in improving student performance.

6.3 Comments on the Research Question: What Perceptions Are Held About 'Creative Maths' in Comparison With 'Maths the Easy Way' for Improving Student Performance?

The purpose of this question in terms of the study was to gather qualitative data that would enable the study to succeed in finding out about perceptions held on the two programmes, 'Creative Maths' and 'Maths the Easy Way' in comparison with each other for improving student performance in mathematics, when students are taught through small-group and whole-class teaching methods by each mathematics teacher, using two different programmes based on the same content of mathematics basic sets theory, with different pedagogies.

From the qualitative data gathered by means of the observation of group classes conducted in the experiment, questionnaires and interviews, there were positive and negative comments on the 'Creative Maths' and 'Maths the Easy Way' in improving student performance. There were, however, more positive comments on 'Creative Maths' than 'Maths the Easy Way', as a result, it was felt that 'Creative Maths' produced better results in improving student performance than 'Maths the Easy Way'. This was a strong feeling by most of the participants engaged in this study. Despite what came out from the qualitative data and participants, the statistical data had something different to say about the two programmes discussed in this study in respect of improving student performance in mathematics when teaching occurred through the small-group and whole-class methods. Note that this strong feeling referred to above has nothing to do with the scores of students and should not in anyway be associated with them (i.e., scores), since the two situations of perceptions of participants and scores of participants were treated separately and are thus

different issues. Perceptions relate more to qualitative data, whereas, scores are more related to quantitative data.

6.4 Significance of 'Creative Maths' and 'Maths the Easy Way'

Both programmes - 'Creative Maths' and 'Maths the Easy Way' - were significantly used by the mathematics teachers to improve student performance. Both programmes were conducted well in the experiment. The statistical data indicated very little difference between 'Creative Maths' and 'Maths the Easy Way' in improving student performance in mathematics. This 'difference' was verified by a further investigation illustrated in Appendix L, showing the success rates between boys and girls taught in the experiment through 'Creative Maths' and 'Maths the Easy Way'. In general, boys performed better (attaining ratings of 50% up to 58%) in comparison to girls (with ratings of 36% up to 50%). Although the differences in boys and girls percentages is not that high (maximum difference = 8%), these percentages still mark some conclusions done in other studies of social research of 'Gender in Mathematics' that boys are more mathematically capable and mathematically inclined than girls. This study was only interested in the overall performance of students in both the mathematics programmes despite their gender. Improvement in student performance is illustrated below in percentages:

Boys: **(50-58)%** improvement across the programmes

Girls: **(36-50)%** improvement across the programmes.

The percentages given above were considered in relation to the mathematics programmes - 'Creative Maths' and 'Maths the Easy Way' - and had the following significance:

'Creative Maths' Gained 50% plus 58% equals 108% whereas 'Maths the Easy Way' gained 36% plus 50% equals 86%. In this comparison illustrated above, there was sufficient proof that 'Creative Maths' came out higher in per cent than 'Maths the Easy Way' and that boys performed better than girls in the experiment.

6.5 Conclusion

In the study it was found that the difference in the programmes 'Creative Maths' and 'Maths the Easy Way' in improving student performance in the experiment was very small having to take into consideration the difference in individual student scores in their Control and Experiment groups, the mean values, the difference of **0.83** and **2.18**, and lastly how the

performance in mathematics of boys compared to girls rose up to the maximum difference value of **8%**. It is, however, **not possible** to analyse and prove the qualitative data arising from the perceptions of various participants in the study. These data were not subjected to any statistical measures or procedures and therefore cannot be relied upon in terms of taking vigorous conclusions, despite all the positive comments that were said in favour of 'Creative Maths' in comparison with 'Maths the Easy Way'. The final conclusion was that it could be said with certainty that neither 'Creative Maths' nor 'Maths the Easy Way' was better in improving student performance. It was concluded that there was either insufficient statistical difference or almost no significant statistical difference between 'Creative Maths' and 'Maths the Easy Way' in improving student performance. The difference in these programmes was very small and it was difficult to arrive at a different conclusion other that the one above. In addition there was no programme on 'which' students performed best, more positive perceptions were held about 'Creative Maths' than 'Maths the Easy Way'. These are the findings with regard to this study.

I, the researcher, hoped that these findings, together with the entire study would be received positively by the schools, teachers, students and officials concerned, as an eye-opener and device to help them reflect back to their planning and management, teaching and learning including budgeting and developing curricula, and most importantly, how all these aspects relate to and affect mathematics inside the classroom. We must seriously create the best ways of teaching mathematics effectively for better outcomes that would contribute to improving student performance in mathematics.

REFERENCES

ANSTEY, G. 1997. *Sunday Times*, 29 June. p.7.

BAILEY, K.D. 1978. *Methods of Social Research* (2nd ed.). New York: The Free Press. pp.3-30, 222-226, 227-235.

BOSSERT, S. 1988. 'Cooperative Activities in the Classroom'. In: E. Rothkopf (ed.). *Review of Research in Education*. Washington, DC: American Educational Research Association. pp.225-250.

BRANDT, R. 1989. *Cooperative Learning*. *Educational Leadership*. 47(4). pp.1-66.

BROM-BACHER, A. 1994. *Stimulus*. A Two-Monthly Publication Focussing on School Management, 2(3). pp.1-30.

BROPHY, J. & GOOD, T.L. 1986. 'Teacher Behaviour and Student Achievement'. In: M. Wittrock (ed.). *Handbook of Research on Teaching* (3rd ed.). New York: McMillan, pp.328-375.

CANADY, R. & HOTCHKISS, P. 1985. 'Scheduling Practices and Policies Associated with Increase Achievement for Low-Achieving Students'. *Journal of Negro Education*. 54(3). pp.334-355.

CATES, W.M. 1985. *A Practical Guide to Educational Research*. New Jersey: Prentice-Hall. p.124.

CLEMENT, J., LOCKHEAD, J. & MONK, S. 1981. 'Translation Difficulties in Learning Mathematics'. *American Mathematical Monthly*, pp.286-290.

COHEN, L. & MANION, L. 1980. *Research Methods in Education* (2nd ed.). London: Croom Helm. pp.78-79, 191, 199.

CRAWFORD, J. 1989. 'Teaching Effectiveness in Classrooms'. *Elementary School Journal.* pp.33-46.

DOWNING, J. 1967. *Evaluating the Initial Teaching Alphabet.* London: Cassel. pp.25-28.

DURKHEIM E. 1895. *The Rules of Sociological Method.* English translation, edited by G.E.C. Catlin (1950). Free Press of Glencoe. p.25.

ELLERTON, N.F. & CLEMENTS, M.A. 1989. *School Mathematics: The Challenge to Change.* Victoria: Deakin University. pp.150-152.

FISHER, C. 1978. 'Teaching Behaviour, Academic Learning and Student Achievement'. *Final Report on Phase III-B, Beginning Teacher Evaluation Study.* Tech. Rep. Vol. 1. San Francisco, CA: Far West Laboratory for Educational Research and Development. P.13.

FISHER, C. 1980. 'Teaching Behaviour, Academic Learning Time and Student Achievement: An Overview'. In: C. Denham and A. Ucherman (Eds) *Time to Learn.* Washington, DC: National Institute of Education. pp.7-90.

FISHER, R.A. 1935. *The Design of Experiments.* Edinburgh: Oliver and Boyd. p.1.

GARMORAN, A. 1989. 'Organization, Instruction and the Effects of Ability Grouping: Comments on Slavin's "Best-Evidence Synthesis"'. *Review of Educational Research.* 57(4). pp.341-342.

GERLEMAN, S. 1987. 'An Observational Study of Small-Group Instruction in Fourth-Grade Mathematics Classrooms'. *Elementary School Journal.* pp.3-28.

GOOD, T., REYS, B., GROUWS, D. & MULRYAN, C. 1983. *Using Work Groups in Mathematics Instruction. Educational Leadership.* New York: Longman. 47(4). pp.56-62.

GOODLAD, J.I. & OAKES, J. 1988. 'We Must Offer Equal Access to Knowledge'. *Educational Leadership.* 45(5). pp.16-22.

GRAHAM, B. 1988. 'Mathematical Education and Aboriginal Children'. *Educational Studies in Mathematics.* pp.119-135.

GROUWS, D. & COONEY, T. 1987. *Perspectives on Research on Effective Mathematics Teaching,* (Eds) Vol. 1. Hillsdale, NJ: Earlbaum. pp.68-89.

HARVEY, T.J. & COOPER, C.J. 1978. 'An Investigation into Some Possible Factors Affecting Children's Understanding of the Concept of Electric Circuit in the Age Range 8 - 11 Years Old'. *Educational Studies.* pp.149-155.

HAYLOCK, D. 1991. *Teaching Mathematics to Low Attainers.* London: PCP, pp.1-36.

HENWOOD, K. & PIDGEON, N. 1992. 'Qualitative Research and Psychological Theorizing'. *British Journal of Psychology.* pp.97-111.

HIEBERT, E. 1987. 'The Context of Instruction and Student Learning: An Examination of Slavin's Assumptions'. *Review of Educational Research.* 57(3). pp.333-340.

HILL, A.B. 1962. *Statistical Methods in Clinical and Preventive Medicine.* New York: Oxford University Press. p.35.

HUNTING, R.P. 1987. 'Issues Shaping School Mathematics Curriculum Development in Australia'. *Curriculum Perspectives.* pp.29-37.

KERLINGER, F.N. 1986. *Foundations of Behavioural Research* (3rd ed.). New York: CBC Publishing Japan Ltd. p.417.

KRISCH, F. 1997. *The Star*, (TIMS). 6 May. p.2.

LEEDY, P.D. 1989. *Practical Research: Planning and Design* (4th ed.). New York: Appleton-Century-Crofts. pp. 78-102.

LEINHARDT, G. 1988. 'Expertise in Instructional Lessons: An Example From Fraction'. In: D. Grouws & T. Cooney (eds). *Perspectives on Research on Effective Mathematics Teaching* Vol. 1. Hillsdale, NJ: Earlbaum. pp.47-66.

LINDQUIST, M. 1989. 'Mathematics Context and Small-Group Instruction in Grades Four Through Six'. *Elementary School Journal.* pp.625-632.

LUND, F.J. 1990. *Evaluation of the Education Policy Unit - University of the Witwatersrand.* Centre for Social and Development Studies. Durban: University of Natal. pp.1-2, 30, 32, 41.

MATHEMATICS FRAMEWORK FOR CALIFORNIA PUBLIC SCHOOLS. 1985. Sacramento, CA: Department of Public Instruction, pp.1-25.

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS (NCTM). 1989. *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: NCTM. pp.15-23.

NODDINGS, N. 1985. 'Small Groups as a Setting for Research on Mathematical Problem Solving'. In: E. Silver (ed.). *Teaching and Learning Mathematical Problem Solving: Multiple Research Perspectives.* Hillsdale, NJ: Earlbaum, pp.345-359.

NODDINGS, N. 1989. 'Theoretical and Practical Concerns About Small Groups in Mathematics.' *Elementary School Journal*, pp.607-623.

NORDIN, A.B. 1990. 'Improving Learning: An Experiment in Rural Primary Schools in Malaysia'. In: *Evaluation in Education*, Vol. 4. Great Britain: Pergamon Press. pp.143-263.

PARLETT, M. & HAMILTON, D. 1972. *Evaluation as Illumination: A New Approach to the Study of Innovations Programs.* Occasional Paper No. 9. Centre for Research in the Educational Sciences, University of Edinburgh. p.90.

ROSENSHINE, B. 1979. 'Content, Time and Direct Instruction'. In: P.Peterson and H. Walberg (eds). *Research on Teaching: Concepts, Finding and Implications.* Berkeley: McCutchan. p.48.

ROSENSHINE, B. & STEVENS, R. (1986). 'Teaching Functions'. In: M. Wittrock (ed.). *Handbook of Research on Teaching* (3rd ed.). New York: McMillan. pp.376-391.

ROSENTHAL, R. & JACOBSON, L. 1996. 'Teacher's Expectancies: Determinants of Pupils' IQ Gains'. *Psychological Reports.* Vol. 19 (Aug - Dec). pp.115-118.

SCRIVEN, M. 1967. 'The Methodology of Evaluation'. In: R.E. Stake (ed.). 1967. *Curriculum Evaluation.* AERA Monograph Series in Education No. 1. Chicago: Rand McNally. p.5.

SELLTIZ, C., WRIGHTSMAN, L.J. & COOK, S.W. 1976. *Research Methods in Social Relations.* (3rd ed.). New York: Hold, Rinehart and Winston. pp.1-125.

SIEGEL, S. 1956. *Non-Parametric Statistics for the Behavioural Sciences.* Tokyo: McGraw-Hill. pp.19-83.

SIMON, D.P. & SIMON, H.A. 1978. 'Individual Differences in Solving Physics Problems'. In: R.S. Siegler (ed.). 1978. *Children's Thinking: What Develops?* New Jersey: Earlbaum. p.413.

SLAVIN, R. 1989. 'Cooperative Learning and Student Achievement'. In: R. Slavin (ed.). *School and Classroom Organization.* Hillside, NJ: Earlbaum, pp.129-156.

SLAVIN, R. 1987. 'Ability Grouping and Student Achievement in Elementary Schools. A Best-Evidence Synthesis' *Review of Educational Research,* 57(3), 293-336.

SOLOMON, R.L. 1949. 'An Extension of Control Group Design'. *Psychology Bulletin.* pp.137-150.

TUCKMAN, B.W. 1978. *Conducting Educational Research* (2nd ed.). USA: Harcourt Brace Jovanovich. pp.58-67, 441-442.

VERHONICK, P.J. & SEAMAN, C.C. 1978. *Research Methods for Undergraduate Students in Nursing.* New York: Appleton-Century-Crafts. p.30.

WEISS, V. 1971. 'The Teaching of Mathematics and the Development of Intelligence in the First Year at School'. In: *Frankfurt Project Reports No. 4,* Seminar for the Teaching of Mathematics. University of Frankfurt-on-Main. pp.21-22.

ZOLKOV, A.M. 1986. The Use of Computers in Music Education in South West Africa. Thesis (M. Mus), University of the Witwatersrand,. pp.1-360.

APPENDICES



APPENDIX A

THE STRUCTURE OF THE PROGRAMMES

Sample Selected Randomly N = 40

MATHEMATICS PROGRAMMES	CONTENT (Unit One)	MATHEMATICS TEACHERS	CONTENT (Unit Two)
'Maths the Easy Way' (Control)	Concepts on Sets 1-4	Teacher A	Concepts on Sets 5-8
'Creative Maths' (Experimental)	Concepts on Sets 1-4	Teacher B	Concepts on Sets 5-8

APPENDIX B

STUDENT RECORDS AND STATISTICAL DATA OF THE PRE-TEST

TREATMENT C					TREATMENT E				
No.	Age	Sex	Language	Pre-Test	No.	Age	Sex	Language	Pre-Test
1	15	M	Zulu	50.00	21	14	F	Tswana	55.00
2	15	M	Zulu	49.00	22	15	F	Tswana	52.00
3	15	F	Sotho	48.00	23	15	F	Tswana	45.00
4	15	F	Tswana	52.00	24	15	F	Tswana	60.00
5	15	F	Sotho	60.00	25	14	M	Tswana	59.00
6	14½	M	Tswana	51.00	26	15	F	Sotho	50.00
7	14	F	Sotho	54.00	27	14	M	Tswana	53.00
8	15	M	Tswana	56.00	28	14½	F	Sotho	54.00
9	15	F	Zulu	56.00	29	15	M	Sotho	48.00
10	15½	F	Zulu	59.00	30	15	F	Zulu	45.00
11	15	M	Tswana	58.00	31	15	M	Zulu	55.00
12	15	M	Tswana	65.00	32	14	F	Zulu	58.00
13	15	M	Tswana	60.00	33	14	M	Sotho	52.00
14	14	M	Sotho	62.00	34	15	F	Sotho	47.00
15	14	M	Sotho	51.00	35	14	M	Sotho	64.00
16	15	F	Tswana	50.00	36	15	M	Tswana	52.00
17	15	F	Sotho	50.00	37	15	F	Tswana	66.00
18	14	M	Zulu	53.00	38	14½	F	Zulu	58.00
19	15	M	Zulu	65.00	39	14	M	Sotho	62.00
20	15	M	Tswana	47.00	40	15	F	Tswana	56.00
Mean				54.80	Mean				54.60
Standard Deviation				5.61	Standard Deviation				5.97
Minimum Values				47.00	Minimum Values				45.00
Maximum Values				65.00	Maximum Values				66.00

APPENDIX C

STATISTICAL DATA OF THE SIGNED-RANKS TEST: POST-TEST ONE

(Test of Effect of Treatments)

TREATMENT C		TREATMENT E	
No.	Post-Test One	No.	Post-Test One
1	71.00	21	47.00
2	83.00	22	71.00
3	47.00	23	64.00
4	86.00	24	52.14
5	51.00	25	50.00
6	95.35	26	100.00
7	45.00	27	90.00
8	60.00	28	70.13
9	53.00	29	75.00
10	48.00	30	49.13
11	65.00	31	53.00
12	54.00	32	68.00
13	80.00	33	82.00
14	67.13	34	80.00
15	70.00	35	53.00
16	68.00	36	56.00
17	59.34	37	63.40
18	79.00	38	65.00
19	58.13	39	85.00
20	62.00	40	66.14
Mean	65.09		67.02
Std. Dev.	14.09		14.86
Min. Val	45.00		47.00
Max. Val	95.35		100.00

APPENDIX D

STATISTICAL DATA OF THE SIGNED-RANKS TEST: POST-TEST TWO (Test of Effect of Treatments)

TREATMENT C		TREATMENT E	
No.	Post-Test Two	No.	Post-Test Two
1	50.00	21	72.00
2	70.00	22	85.00
3	67.00	23	48.00
4	54.32	24	88.22
5	53.00	25	54.00
6	97.00	26	98.00
7	87.34	27	52.00
8	65.00	28	67.00
9	71.00	29	54.00
10	43.00	30	50.00
11	55.00	31	66.00
12	69.00	32	59.00
13	85.00	33	86.00
14	81.00	34	69.00
15	55.00	35	73.00
16	58.00	36	66.00
17	69.00	37	58.00
18	64.00	38	80.00
19	81.13	39	59.00
20	67.00	40	69.14
Mean	67.09		67.67
Std. Dev.	13.9		14.3
Min. Val.	43.00		48.00
Max. Val.	97.00		98.00

APPENDIX E

STATISTICAL DATA OF THE WILCOXON MATCHED-PAIRS SIGNED RANKS TEST: POST-TEST ONE (Test of Difference Between the Treatments)

TREATMENT C		TREATMENT E	
No.	Post-Test One	No.	Post-Test One
1	71.00	21	47.00
2	83.00	22	71.00
3	47.00	23	64.00
4	86.00	24	52.14
5	51.00	25	50.00
6	95.35	26	100.00
7	45.00	27	90.00
8	60.00	28	70.13
9	53.00	29	75.00
10	48.00	30	49.13
11	65.00	31	75.00
12	54.00	32	53.00
13	80.00	33	68.40
14	67.13	34	82.00
15	70.00	35	80.00
16	68.00	36	53.00
17	59.34	37	56.00
18	79.00	38	63.00
19	58.00	39	85.00
20	62.00	40	66.00
Mean	69.09		67.02
Std. Dev.	14.90		14.86
Min. Val.	45.00		47.00
Max. Val.	95.35		100.00

APPENDIX F

STATISTICAL DATA OF THE WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST: POST-TEST TWO
(Test of Difference Between the Treatments)

TREATMENT C		TREATMENT E	
No.	Post-Test One	No.	Post-Test One
1	50.00	21	72.00
2	70.00	22	85.00
3	67.00	23	48.00
4	54.32	24	88.22
5	53.00	25	54.00
6	97.00	26	98.00
7	87.34	27	52.00
8	65.00	28	67.00
9	71.00	29	54.00
10	43.00	30	50.00
11	55.00	31	66.00
12	69.00	32	59.00
13	85.00	33	86.40
14	81.00	34	69.00
15	55.00	35	73.00
16	58.00	36	66.00
17	69.00	37	58.00
18	64.00	38	80.00
19	81.13	39	59.00
20	67.00	40	69.14
Mean	67.09		67.67
Std. Dev.	13.90		14.03
Min. Val.	43.00		48.00
Max. Val.	97.00		98.00

APPENDIX G

LETTER TO STUDENTS

P O Box 8493
JOHANNESBURG
2000
2 January 1995

Dear Student

As you know, the study on the teaching of mathematics has been in progress since early January 1995 at your school. Because you have been selected as participants in this study, you are required amicably and kindly to fill in and complete the questionnaire attached herewith.

As formerly explained the present study is important. Your careful thought and your opinion of this study are crucial for this study to be completed.

Therefore, I ask you to take some time and respond to the questions asked by putting on the space provided an appropriate number. There are numbers (1-5) given for each section. Altogether there are four sections: 1 = Disagree strongly; 2 = Disagree; 3 = Not sure; 4 = Agree; and 5 = Agree strongly.

This questionnaire is not a test and no 'right' answers are expected. This is simply a series of questions which you must answer to the best of your ability and as honestly as possible.

You are not required to fill in your name on the questionnaire. The questionnaire will be handled in the strictest of confidence.

Yours sincerely

Letho

PAUL LETHO

APPENDIX H

STUDENT QUESTIONNAIRE

Instruction: Encircle either a positive or negative statement first (not both) and then fill in the appropriate number in the space provided opposite the statement chosen.

Mathematics Department
Course Evaluation

Name of Course: _____
Name (Optional): _____ Date: _____

I.	The Course Itself	(5)	(4)	(3)	(2)	(1)	
	Liked it	-	-	-	-	-	Did not like it
	Too hard	-	-	-	-	-	Too easy
	Good methods for learning	-	-	-	-	-	Poor methods
	Changed my attitudes about mathematics	-	-	-	-	-	Did not change my attitude
	Would recommend	-	-	-	-	-	Would not recommend
	Too much homework	-	-	-	-	-	No homework
	Clear assignments and due dates	-	-	-	-	-	Unclear assignments and due dates
II.	You as Student	(5)	(4)	(3)	(2)	(1)	
	Well-prepared for class	-	-	-	-	-	Poorly prepared
	Show interest in class	-	-	-	-	-	Show no interest
	Ask for help in class when needed	-	-	-	-	-	Do not ask for help in class
	Ask for help outside of class when needed	-	-	-	-	-	Do not ask for help outside of class
	Put best effort into homework	-	-	-	-	-	Put little effort
	Make it fun for the teacher	-	-	-	-	-	Do not make it fun
	Have learned something	-	-	-	-	-	Are more confused
III.	The Teacher	(5)	(4)	(3)	(2)	(1)	
	Well-prepared	-	-	-	-	-	Poorly prepared
	Interesting	-	-	-	-	-	Uninteresting
	Fair	-	-	-	-	-	Unfair
	Too hard	-	-	-	-	-	Too easy
	Presents enough variety	-	-	-	-	-	Does not present it
	Offers enough help	-	-	-	-	-	Does not offer help
IV.	Methods	(5)	(4)	(3)	(2)	(1)	
	Like the cumulative method of homework	-	-	-	-	-	Do not like cumulative homework
	See the value of the cumulative method in homework	-	-	-	-	-	Does not see its value
	See the value of weekly tests	-	-	-	-	-	Do not see its value
	Find it easy to study for tests	-	-	-	-	-	Do not find it easy
	Plan to take more mathematics in school than I would have normally	-	-	-	-	-	Do not plan to take more mathematics than normal

Please write any additional comments that you would like to make concerning how to improve this course, your thoughts and feeling about the course, and so on at the back of this paper. Thank you so much!

1 = Disagree strongly; 2 = Disagree; 3 = Not sure; 4 = Agree; 5 = Agree strongly

APPENDIX I

QUESTIONNAIRE: MATHEMATICS TEACHERS

COMPARING 'CREATIVE MATHS' AND 'MATHS THE EASY WAY'

Evaluate each item:

S = Strong = 5;

M = Moderate = 3;

N = Needs attention = 1

	S	M	N
1. Commitment to teaching goals and objectives			
2. Appropriate teaching methods			
3. Trust and mutual understanding of the learning-teaching process			
4. Class participation and interaction			
5. Open and effective classroom communication			
6. Sharing of ideas and resources			
7. Lesson preparation			
8. Presentation of lessons			
9. Individual attention paid			
10. Handling of activities			
11. Climate of mutual support and assistance			
12. Openness to new ideas and challenges			
13. Progress reviewed periodically			
14. Improve student performance			
15. Enjoy teaching mathematics			
16. Strong motivation and group morale			
17. Teaching confidence			
18. Teaching expertise			
19. Roles and responsibilities clear to all			
20. OVERALL TEAM EFFECTIVENESS			

APPENDIX J

INTERVIEW: MATHEMATICS TEACHERS

Mathematics Department

1. Do you think the investigation mode is important in a mathematics classroom? Explain.

2. Is discussion in teaching mathematics vital? Explain.

3. Have you enjoyed being part of this experiment? Explain.

4. What do you think of the two mathematics training programmes used in the experiment? Elaborate.

APPENDIX K

INTERVIEW: DET OFFICIALS

Mathematics Department

1. Is evaluation of student progress necessary in a mathematics classroom?

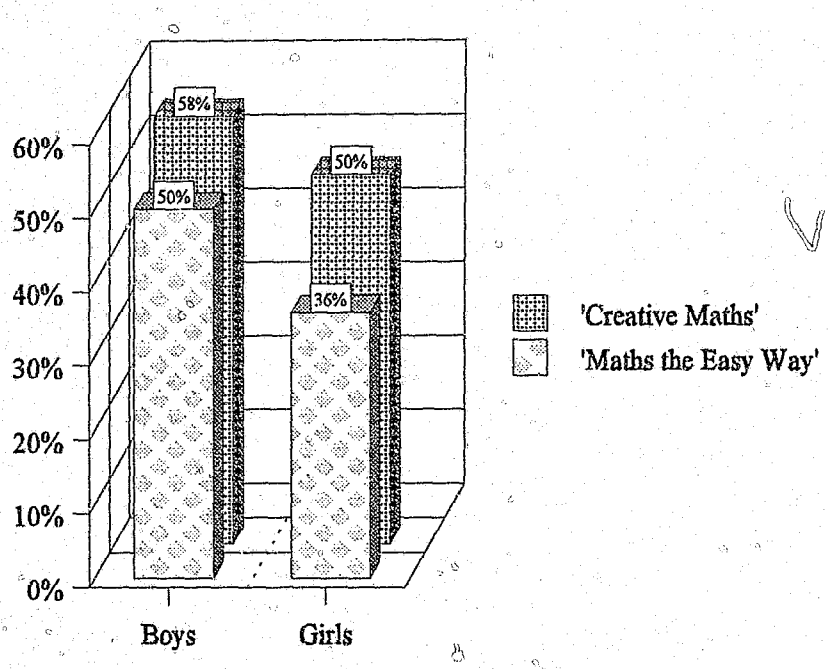
2. Are mathematics students exhibiting any attitudes as they learn in the classroom?

3. Is investigation and discussion important in mathematics? Explain.

4. What are the kinds of things students learn in mathematics to improve performance?

APPENDIX L

SUCCESS RATES



PRE-TEST AND POST-TESTS

PRE-TEST

NAME: _____ CLASS: _____

SCHOOL: _____

Read each question carefully and select your answer by putting a (✓) on the letter you have selected.

(1) (1, 2, 3) =
(A) (2, 3, 4)
(B) (1, 2, 3, 4)
(C) (4, 2, 3)

(2) If P = (even numbers less than 10)
(A) (8, 4, 6, 2)
(B) (3, 5, 7, 9)
(C) (3, 4, 5, 6, 7, 9)
(D) (2, 4, 9, 8)

(3) If X = (goat, buffalo, cow, duck, cat)
Y =
(A) (animals with four legs)
(B) (domestic animals)
(C) (pet animals)
(D) (animals found only in this country)

(4) If C = (orange, blue, yellow, red, green)
Which of the following is not true?
(A) black $\notin$ C
(B) blue $\notin$ C
(C) orange $\notin$ C
(D) brown $\notin$ C

(5) If P = (even numbers less than 10)
and Q = P
Therefore Q =
(A) (8, 6, 2, 4)
(B) (3, 5, 7, 9)
(C) (2, 3, 4, 5, 6, 7, 8, 9)
(D) (3, 2, 8, 7, 4)

(6) If W = (pot, bucket, hammer, box, ladder)
K = W
Therefore the number of elements in K is
(A) 3
(B) 2
(C) 4
(D) 5

(7) If X = (g, k, l, t)
Y = (g, m, t, l)
M = (t, k, l, g)
N = (w, m, g, k)
Therefore
(A) X = Y
(B) Y = M
(C) M = N
(D) X = M

(8) If S = (eagle, swallow, parrot ...)
Complete S
(A) duck, crow
(B) duck, frog
(C) duck, cow
(D) duck, cat

(9) If J = K
L = J
J = {2, 1, 11, 15, 6}
Which is not true?
(A) L = {6, 1, 11, 2, 15}
(B) K = {3, 5, 7, 4, 12}
(C) K = {11, 1, 15, 2, 6}
(D) L = {15, 11, 6, 1, 2}

(10) If a ∈ F
H = F
Therefore
(A) H = {c, a, t, s}
(B) H = {a, c, s, t}
(C) H = {c, t, s, b}
(D) H = {t, a, s, c}

(11) If M = {first six months of the year}
N = {second six months of the year}
Which is not true?
(A) M = N
(B) M = N
(C) N = M
(D) N ≠ M

(12) If hat ∈ B
B = C
C = {boot, chair, hat, button, cup}
Therefore
(A) B = {button, chair, hat, cup, boot}
(B) B = {chair, button, desk, cup, plate}
(C) B = {chair, hat, cup}
(D) B = {desk, chair, cup}

(13) If Z = {3, 9, 24, 16, 5, 12}
Which of the following sets is equivalent to Z?
(A) {5, 12, 18, 24, 3, 9}
(B) {2, 3, 4, 5, 6, 7}
(C) {3, 12, 18, 12}
(D) {3, 9, 5}

(14) p is an element of which set?

(A) {e, a, r, t, h}
(B) {v, e, n, u, s}
(C) {j, u, p, i, t, e, r}
(D) {m, a, r, s}

(15) If B = (Kuala Lumpur, Hong Kong, Manila ...)
B can appropriately be described as
(A) {capital cities in the world}
(B) {main ports in Asia}
(C) {capital cities in Asia}
(D) {main towns in South East Asia}

(16) If K = {mat, mattress ...}
Complete K so that it has six elements
(A) {hat, knife, pot, plate}
(B) {pillow, blanket, bed, net}
(C) {chair, book, pen, pencil}
(D) {knife, spoon, bread, bowl}

(17) {wild animals found in this country} =

(A) {lion, tiger, kangaroo}
(B) {tiger, dog, crocodile}
(C) {crocodile, tiger, monkey}
(D) {duck, snake, giraffe}

(18) P = { □, ▽ }
Q = { ○, □, ◇, ▽ }
Which elements need to be deleted to make P = Q?
(A) { ○, ◇ }
(B) { □, ▽ }
(C) { ○, ▽ }
(D) { ◇, □ }

(19) If X = {r, j, c, l, y}
Which of the following is true?
(A) C ∈ X
(B) X = {n, m, o, p}
(C) X has 4 elements
(D) X ≠ {c, y, l ,r, j}

(20) If R = {9, 12, 7, 3}
S = {3, 2, 5}
T = {7, 12, 9, 3}
U = {3, 6, 9, 12}
Which of the following is not true?
(A) R ≠ U
(B) T = R
(C) 3 ∈ S
(D) S ≠ R

POST-TEST ONE

NAME: _____ CLASS: _____

SCHOOL: _____

Read each question carefully and select your answer by putting a (✓) on the letter you have selected.

(1) If M = ( )
Therefore M =
(A) {students in your class less than 5 years old}
(B) {even number divisible by 2}
(C) {vehicles with wheels}
(D) {fruits which are not edible}

(2) If K = {15, 7, 9, 3, 12}
M ⊄ K
Therefore M =
(A) {15, 12, 3}
(B) {7, 3}
(C) {15, 7, 5}
(D) {9, 3, 12}

(3) If Q = {r, j, p, n, k}
S = {m, p, h, j}
R = {n}
T = {j, p, n}
Which is not true?
(A) T ⊂ Q
(B) S ⊂ T
(C) R ⊂ T
(D) R ⊂ Q

(4) E = {fruits found in this country}
P ⊂ E
Therefore P =
(A) {bananas, apples, dates}
(B) {coffee, papayas, rambutans}
(C) {durians, grapes, mangosteens}
(D) {pineapples, langsat, rambutans}

(5) If J = {l, c, k, t, n, o, y}
and M = J
Which is not true about M?
(A) ∅ ⊂ M
(B) It has four elements
(C) M = {c, k, t, n}
(D) t ∉ M

(6) If P = {Kuantan, Ipoh, Kluang, Taiping}
E =
(A) {capital towns for the states in Malaysia}
(B) {towns in Malaysia}
(C) {ports of Malaysia}
(D) {towns in Perak}

(7) If R = {4, 7, 3, 2, 6}
Q = {3, 4, 6}
J ⊄ 0 but J ⊂ R
J =
(A) {6, 4}
(B) {3, 6}
(C) {2, 4}
(D) {4, 3}

(8) If R = {1, 2, 3, 7, 8}
S = {7, 8, 10, 12, 3}
T ⊂ R and T ⊂ S
Therefore T =
(A) {1, 7, 8}
(B) {7, 8, 10}
(C) {12, 1, 8}
(D) {8, 7, 3}

(9) If H = {w, y, z}
How many subsets does H have?
(A) 8
(B) 4
(C) 6
(D) 5

(10) If A = {even numbers less than 20}
B = {even numbers less than 20 divisible by 3}
Which is true?
(A) A ⊂ B
(B) {6, 12, 18} ⊂ A
(C) B ⊄ A
(D) {5, 10, 15} ⊂ A

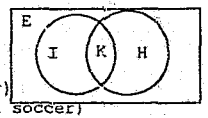
(11) If L = (pupils in your school)
M = (pupils in your place who attend school)
K = (pupils in your class)
Therefore
(A) M ⊂ L
(B) L ⊂ K
(C) K ⊂ M
(D) M ⊂ K

(12) Given M = (18, 19, 20, 21)
N = (20, 21, 22, 23)
Which of the following set is a subset of M and N?
(A) 19, 20
(B) 21, 22
(C) 21, 20
(D) 20, 21, 22

(13) If S = (12, 25, 4, 7, 81)
T = (13, 17, 81, 15, 9)
Therefore S ∩ T =
(A) 81
(B) 12
(C) 9
(D) 17

(14) If K = (8, 13, 27, 6)
H = (9, 27, 14, 5, 31)
Therefore K ∩ H =
(A) (8, 9, 13, 27)
(B) (27, 8, 13, 6, 9, 5, 31)
(C) (31)
(D) ( )

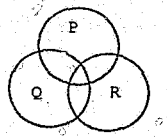
(15) The Venn diagram shows that E = (all students in the school)
H = (all students who play soccer) and
I = (all students who play hockey)
Therefore K =



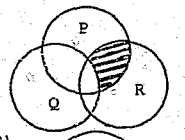
(A) (all students who play hockey only)
(B) (all students who play soccer only)
(C) (all students who play hockey and soccer)
(D) (all students who do not play hockey and soccer)

(16) The diagram below shows that M ∩ N.
If we are to change N ⊂ M, which subject must be left out?
(A) blue, yellow
(B) black, red
(C) white, green
(D) blue, white, red

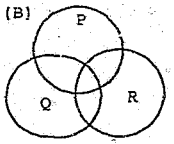
(17) Which shaded area shows that P ∩ Q ∩ R
(A)



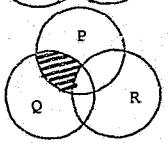
(C)



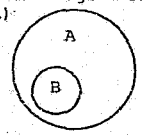
(B)



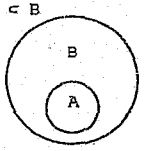
(D)



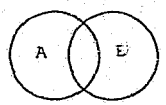
(18) Which diagram shows that A ∩ B and A ⊂ B
(A)



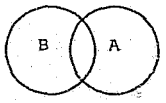
(C)



(B)

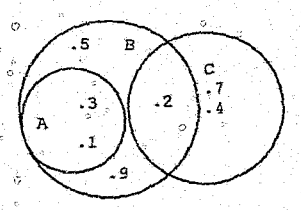


(D)

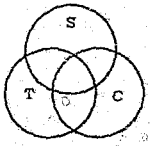


(19) If J = (r, k, i, z, t, u)
K = (i, t, u)
L ∪ K = ( )
L ⊂ J
Therefore L =
(A) (k, t, u)
(B) (r, k, z)
(C) (t, i, k)
(D) (k, i, u)

(20) The diagram below shows that
(A) A ∩ C = ( )
(B) A ∩ B = {5, 9}
(C) A ∪ B = {2}
(D) A ∪ C = {2}



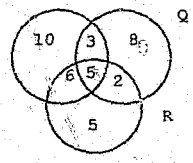
(21) The diagram below shows that
S = {pupils who wear spectacles}
T = {pupils who are in this school}
C = {pupils who have curly hair}
Therefore the shaded area shows that
(A) {pupils who wear spectacles and have curly hair}
(B) {pupils in this school who wear spectacles}
(C) {pupils in this school, have curly hair and wear spectacles}
(D) {pupils in this school who have curly hair}



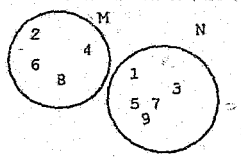
(22) If M = {3, 6, 8, 11, 14}
N = {7, 11, 5, 2}
P = {14, 6}
Therefore
(A) P ∩ N = {14, 6, 7, 11, 5, 2}
(B) P ∩ N = {7, 11}
(C) P ∩ N = {0}
(D) P ∩ N = ( )

(23) If K = {r, t, v, x, i}
L = {v, x, r}
Therefore K - L =
(A) {x, i}
(B) {i}
(C) {i, t}
(D) {t, v}

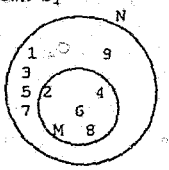
(24) P = {pupils who take geography}
Q = {pupils who take art}
R = {pupils who take carpentry}
How many pupils take both carpentry and art?
(A) 3
(B) 5
(C) 2
(D) 6



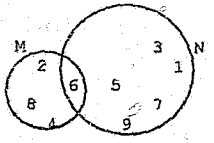
(25) If M = {even numbers less than 10}
N = {odd numbers less than 10}
The relation between M and N can be shown by
(A)



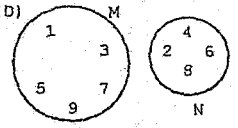
(C)



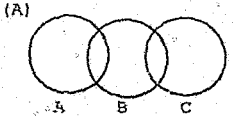
(B)



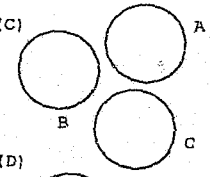
(D)



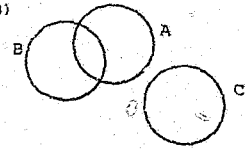
(26) If A ∩ B ∩ C = ∅, which of the following diagrams is not true?
(A)



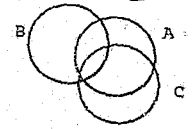
(C)



(B)

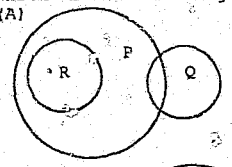


(D)

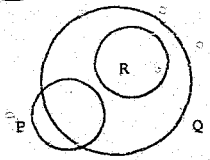


(27) P = {5, 10, 15, 20}
Q = {20, 25, 30, 35, 40}
R = {10, 15}
Which of the following diagrams illustrate that P ∩ Q ∩ R ≠ ∅?

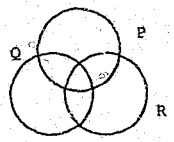
(A)



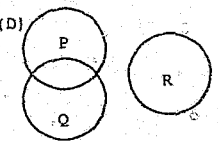
(B)



(C)

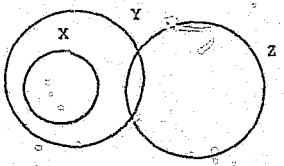


(D)

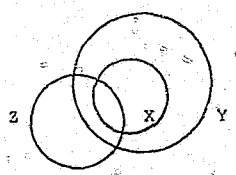


(28) If X ⊂ Y and X ∩ Z = { }
Which of the following diagrams is correct?

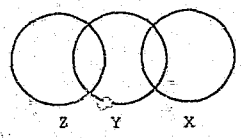
(A)



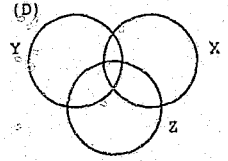
(B)



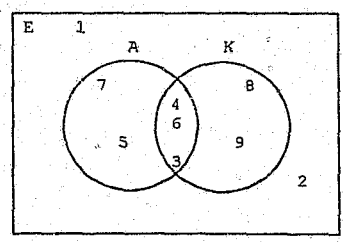
(C)



(D)



(29) In the diagram below A ∩ E =
(A) {7, 5}
(B) {8, 9}
(C) {7, 5, 4, 6, 3}
(D) {4, 6, 3}



POST-TEST TWO

NAME: _____ CLASS: _____

SCHOOL: _____

Read all the questions carefully and answer them on the answer sheet.

(1) {2, 4, 6, 8} =
(A) {round numbers less than 10}
(B) {even numbers less than 10}
(C) {even numbers more than 1}
(D) {round numbers divisible by 2}

(2) Even numbers divisible by 3 =
(A) {30, 20, 10}
(B) {3, 6, 9}
(C) {6, 12, 18}
(D) {2, 4, 6}

(3) Given P = {a, e, i, o, u}
and Q = {b, d, p, t, c}
Which of the following is not true?
(A) e ∈ P
(B) u ∈ Q
(C) i ∈ P
(D) t ∈ Q

(4) Given M = 3, 4, 9, 10, 18
and N = 9, 5, 8, 4, 7
Therefore
(A) N = M
(B) N ⊂ M
(C) M ⊄ N
(D) M = N

(5) Given X = {blue red, yellow, orange}
Y = {red, green, pink, brown}
and Z = {yellow, red, orange, blue}
Which of the following is not true?
(A) red ∈ Y
(B) X = Z
(C) Z = X
(D) pink ∉ Z

(6) If J = {ball, boot, bicycle}
How many subsets are in J?
(A) 8
(B) 4
(C) 6
(D) 2

(7) If M = {snake, crocodile, lizard, worm}
Therefore M =
(A) reptiles
(B) mammals
(C) animals
(D) insects

(8) Given Q = {l, p, s, t, k, n}
Which of the following is true?
(A) {k, n, p, l} ⊄ Q
(B) {k, s, b, k} ⊄ Q
(C) { } ⊄ Q
(D) {s, l, k, n} ⊄ Q

(9) 21 ∈
(A) {numbers divisible by 4}
(B) {numbers divisible by 7}
(C) {numbers divisible by 5}
(D) {numbers divisible by 8}

(10) Given K = ∅
Therefore K =
(A) {month with 29 days}
(B) {insects having 10 pairs of feet}
(C) {adult less than 4 feet tall}
(D) {odd numbers divisible by 4}

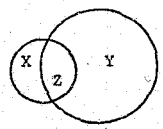
(11) If R = {t, k, w, n, p}
and W = {m, s, p, d}
R ∪ W =
(A) {t, k, w, n, p, m, s, p, d}
(B) {p}
(C) ∅
(D) {m, s, p, d, n, w, k, t}

(12) If F = {5, 10, 15, 20, 25}
G = {10, 20, 30, 40, 50, 60}
Then F ∩ G =
(A) {5, 15, 25}
(B) {30, 40, 50, 60}
(C) {10, 20}
(D) { }

(13) Given X = {b, d, p, h, v}
and Y = {b, d, c, h, v}
Which of the following is true?
(A) k ∈ X
(B) X = Y
(C) {d, v} Y
(D) {c, k} X

(14) If P ⊂ R
and R = {blue, yellow, brown, green}
Which of the following is not true?
(A) P = {blue, black}
(B) P = ∅
(C) P = {blue}
(D) P = {blue, yellow, brown, green}

(15) If X = {1, 2, 3, 4, 5}
and Y = {3, 4, 5, 6, 7}
Using Venn diagram below as a guide, Z =
(A) {3, 2, 1}
(B) ∅
(C) {5, 6, 7}
(D) {3, 4, 5}



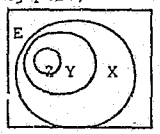
(16) If P = {11, 12, ... 20}
and Q = {2, 4, ... 14}
Then P ∩ Q =
(A) {6, 8, 10}
(B) {20, 14}
(C) {13, 12, 11, 14}
(D) ( )

(17) M ∩ N = ∅
Which of the following is true?
(A) M = {1, 2, 3, 4}; N = {4, 5, 6, 7}
(B) M = {10, 11, 14, 17}; N = {10, 11, 14}
(C) M = {2, 4, 6}; N = {3, 5, 9, 7}
(D) M = {20, 22, 32}; N = {31, 32, 33}

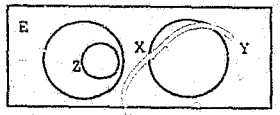
(18) If K = {Monday, Wednesday, Friday, Sunday}
How many subsets are in K?
(A) more than 15
(B) 10
(C) 5
(D) less than 5

(19) If Y = P ∪ Q
Given P = {g, t, o}
and Q = {o, k, j, n}
Therefore
(A) {0}
(B) ∅
(C) {g, t, o, j, k, n}
(D) {g, t, j, o, o, k, n}

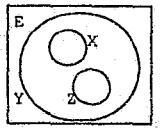
(20) Which of the following Venn diagrams shows:
E = {countries in Asia}
X = {countries in South East Asia}
Y = {China}
Z = {Singapore}
(A)

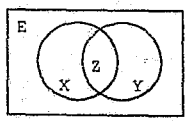


(B)



(C)

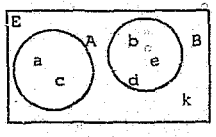




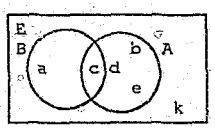
(21) The Venn diagram below indicates that:
(A) Q ⊂ P; Q ∩ R = ∅
(B) R ⊂ Q; P ∩ Q = ∅
(C) P ⊂ Q; R ∩ P = ∅
(D) Q ⊂ R; R ∩ Q = ∅

(22) Which of the following Venn diagrams shows:
E = {a, b, c, d, e, k}
A = {a, c}
B = {b, d, e}

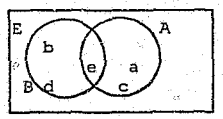
(A)



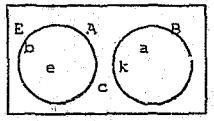
(B)



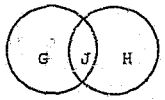
(C)



(D)



(23) In the Venn diagram below G = {people who like movies}
H = {people who like camping}
What do people in J like to do?
(A) {like both movies and camping}
(B) {like only camping}
(C) {like only movies}
(D) {like neither camping nor movies}



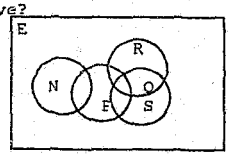
(24) Given X = {students who can swim}
Y = {students in grade six}
Then X ∩ Y =
(A) {students who can swim}
(B) {students in grade six who cannot swim}
(C) {all students who cannot swim}
(D) {students in grade six who can swim}

(25) A group of 120 boys are present in a school house meeting. 40 of them do not play any game. 30 of them play badminton, and 10 of them play sepak-raga and badminton. The rest play soccer. How many boys play sepak-raga?
(A) 10
(B) 0
(C) 20
(D) 30

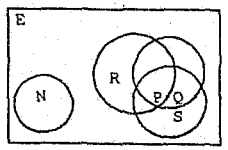
(26) If J = {2, 3, 4, 5, 6}
K = {4, 5, 6, 7, 8}
L = {6, 7, 8, 9, 10}
Then J ∪ K ∪ L has
(A) 9 elements
(B) 15 elements
(C) 5 elements
(D) 7 elements

(27) If E = {boys who attend a school house meeting}
N = {boys who do not play any game}
P = {boys who play badminton and sepak-takraw}
Q = {boys who play sepak-takraw}
R = {boys who play sepak-takraw, soccer and badminton}
S = {boys who play soccer}
Which of the following Venn diagrams illustrates the problem above?

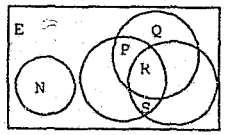
(A)



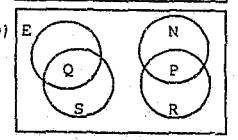
(B)



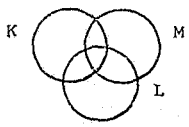
(C)



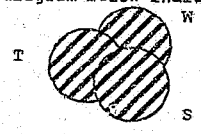
(D)



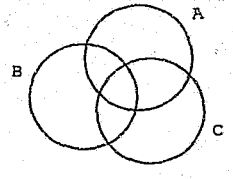
(28) In the Venn diagram below K ∩ H =
(A) {1, 4}
(B) {4}
(C) {1, 4, 5, 2}
(D) {3, 5, 1, 4, 7, 2}



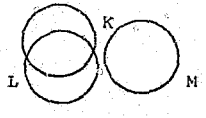
(29) The shaded parts of the Venn diagram below indicates:
(A) T ∪ H ∪ S
(B) T ∩ W ∩ S
(C) T ∩ W ⊂ S
(D) T ∪ W ∩ S



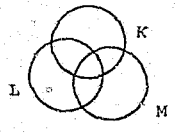
(30) A = {students who are members of mathematics club}
B = {students who are members of historical society}
C = {students who are members of badminton club}
How many students are in both badminton and mathematics clubs?
(A) 15
(B) 20
(C) 25
(D) 10



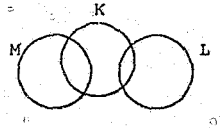
(31) Which of the following Venn diagrams shows that
K = {1, 2, 3, 4}
L = {3, 4, 5, 6}
M = {9, 10, 2, 1}
(A)



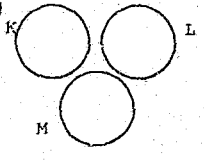
(B)



(C)



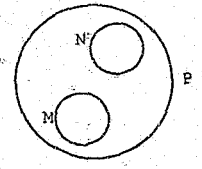
(D)



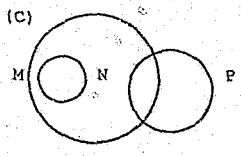
(32) Which of the following Venn diagrams shows that:
N ⊂ P and M ∩ N = ∅
(A)



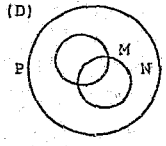
(B)



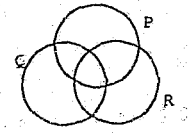
(C)



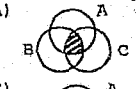
(D)



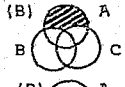
(33) The shaded part of the Venn diagram below is:
(A) P ∩ Q ∩ R
(B) R ∩ P
(C) Q ∩ R
(D) P ∩ Q



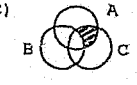
(34) Which Venn diagram shows that A ∩ B ∩ C
(A)



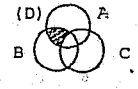
(B)



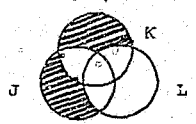
(C)



(D)

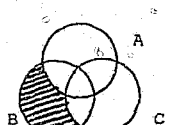


(35) If J = (boys who like to listen to music)
K = (boys who like to read books)
L = (boys who live in this town)
Using the Venn diagram below indicate what the shaded area means.
(A) (boys who live in this town and like to read books)
(B) (some boys like to listen to music and some like to read)
(C) (some boys live in this town and like to listen to music)
(D) (boys who live in this town, like to read books and listen to music)

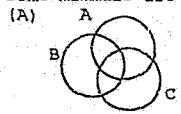


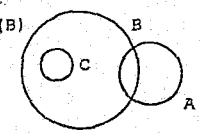
(36) Area A has a population of 800 people. 200 of them read Utusan Melayu; 100 read Strait Times; 300 do not read any paper; 30 read Utusan Melayu, Berita Harian and Strait Times; and 100 read Berita Harian, How many read both Berita Harian and Strait Times?
(A) 50
(B) 300
(C) 25
(D) Insufficient evidence

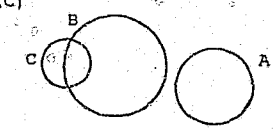
(37) In the Venn diagram below
A = (cats)
B = (pets)
C = (animals which eat fish)
The shaded area indicates:
(A) (some cats eat fish)
(B) (some cats are pets)
(C) (some pets are not cats)
(D) (some pets eat fish)

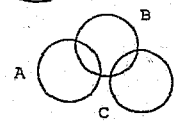


(38) If A = (mammals)
B = (good swimmers)
C = (cold blooded animals)
Which of the following Venn diagrams show that:
All cold blooded animals are good swimmers.
Some mammals are good swimmers.

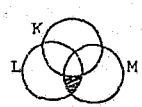
(A)


(B)


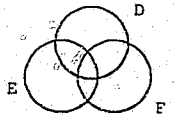
(C)


(D)


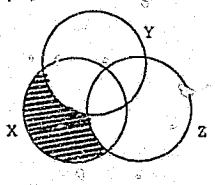
(39) If K = (animals which lay eggs)
L = (birds capable of flying)
M = (animals which are domesticated)
Which of the following statements describe the shaded area?
(A) (some birds are capable of flying, and they are domesticated and do not lay eggs)
(B) (some birds are capable of flying, lay eggs and are not domesticated)
(C) (some animals are domesticated and lay eggs but are not capable of flying)
(D) (some domesticated birds are not capable of flying but lay eggs)



(40) If D = (people who are taller than 5 feet)
E = (people who play soccer)
F = (people who attend evening school)
Which of the following is correct about the shaded area in the Venn diagram below?
(A) (people who are taller than 5 feet, attend evening school and play soccer)
(B) (people who are shorter than 5 feet, do not attend evening school and do not play soccer)
(C) (people who are shorter than 5 feet, play soccer and do not attend evening school)
(D) (people who are taller than 5 feet, do not play soccer and do not attend evening school)

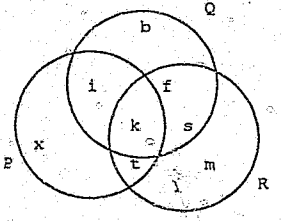


(41) If X = (boys who collect stamps)
Y = (boys who collect match boxes)
Z = (boys who collect bus tickets)
How many boys collect stamps, bus tickets and both stamps and bus tickets?
(A) 12
(B) 20
(C) 29
(D) 57

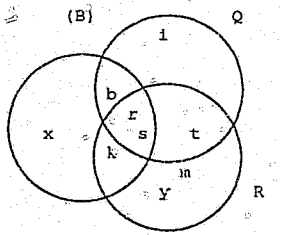


(42) Which Venn diagram shows that:
P = (t, k, j, x)
Q = (j, k, s, r, b)
R = (t, k, r, s, m, y)

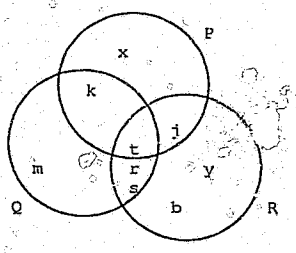
(A)



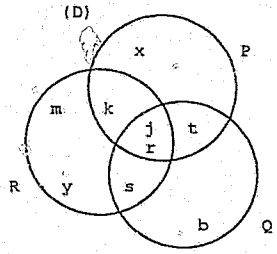
(B)



(C)



(D)



Author Letho P
Name of thesis The Teaching Of Mathematics In Soweto Secondary Schools Trhough Creative Maths (Malaystan) And Maths The Easy Way (Det) Programmes: A Comparative Study Letho P 1998

PUBLISHER:
University of the Witwatersrand, Johannesburg
©2013

LEGAL NOTICES:

Copyright Notice: All materials on the University of the Witwatersrand, Johannesburg Library website are protected by South African copyright law and may not be distributed, transmitted, displayed, or otherwise published in any format, without the prior written permission of the copyright owner.

Disclaimer and Terms of Use: Provided that you maintain all copyright and other notices contained therein, you may download material (one machine readable copy and one print copy per page) for your personal and/or educational non-commercial use only.

The University of the Witwatersrand, Johannesburg, is not responsible for any errors or omissions and excludes any and all liability for any errors in or omissions from the information on the Library website.