THE USE OF COMPUTERS AND PROBLEM SOLVING IN ALGEBRA

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Submitted to the Faculty of Education in fulfilment of the requirements for the degree of Master of Education, in the Department of Mathematics, Science and Technology Education at the University of Zululand

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Date : January 2008

DECLARATION

I, Khetha Bonginkosi Biyela hereby declare that "*The use of the computers and problem solving in algebra*" is my own work both in conception and execution and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

Signed by ______________________

on the ___31___ day of ___MARCH___ 2006.

ABSTRACT

The present study is about the problem solving and the use of computer in teaching and learning of mathematics. The study was conducted to grade eight learners where basic mathematics concepts are introduced. The reason is that lack of knowledge of basic mathematics concepts, irrelevant approaches and methods used in teaching mathematics are perceived as the cause of poor performance in mathematics. Therefore if learners could master these concepts and acquire problem solving skills at elementary level they can do better in upper levels especially in grade 12. In this regard the effects of problem solving involving the use of computer at grade eight level have been investigated.

The first aim was to test the effects of multidimensional approach using computer in algebra problem solving. The second aim was to determine the effects multiple representations in computer environment have on mathematics problem solving. The third aim was to determine the effects of computer assisted collaborative learning on mathematics problem solving.

To achieve these aims an unstandardised achievement test and a questionnaire was administered to a sample of grade eight learners from three high schools in KwaZulu Natal. The results revealed that if problem solving is integrated with other components (dimensions) such as the teaching of facts and skills, teaching for understanding and the use of technology (computer) learners are likely to achieve better results in mathematics.

The results also revealed that the use of multiple representations in expressing the mathematical concept or idea and collaboration among learners in problem solving improve learners' understanding of mathematics.

The discussion of the results of this study leads to the discussion of implications of the findings and recommendations.

ACKNOWLEDGEMENTS

I wish to express my gratitude to the people mentioned below for their invaluable assistance they provided to me during this study.

- Dr D.C. Sibaya, Acting Head of Department, at the University of Zululand, my promoter for her constructive criticism in writing.

- Professor P.T. Sibaya, my co-supervisor for his contribution.

- Mr. R.M. Njisane for his assistance during the fieldwork, and ensuring that the computer program and the instruments for the study were available.

- Mr R. Wilkinson from University of Zululand - Public Relations Office, for editing my study.

- Mr A.A. Ndou – Mathematics statistics Department who helped me with statistics.

- Mr. A.L. Olivier at the University of Stellenbosch for allowing me to use his research instruments for this study.

- The University of Zululand Research Committee for giving me financial assistance.

- The principals and mathematics educators of the three high schools in Empangeni district for allowing me to conduct the research in their schools and their willing cooperation in the administration of the instruments.

- My wife Zenzile who encouraged me to complete this study and also our children Mbali, Nomvelo, Nhlakanipho and Mnqobi for being patient to me during the study.

- Finally I thank God who made it possible for me to accomplish my goals.

DEDICATION

This work is dedicated to my wife Zenzile Mamma Biyela (MaMhlongo) who supported me throughout my studies. Her sacrifices and motivation contributed a lot to my education. May the God Almighty be with her for the contribution she made to my success.

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CHAPTER ONE

MOTIVATION FOR THE STUDY

1.1 INTRODUCTION

Mathematics has always been perceived as the most difficult subject in the school curriculum. This has resulted in learners having a negative attitude toward the subject, and this attitude seems to have passed from one generation to the next – up to today. Learners, including adults, who have failed mathematics preserve this image of failure and justify their failure by devaluing the importance of the subject – an attitude that affects the efforts that educators put into their teaching of mathematics (Richard in Cornelius, 1982). As a consequence of this situation, it is not surprising to find a prevalent high failure rate in mathematics and a lack of motivation in learners which directly de-motivates the educators. This problem is evident when one looks at matric results and also at the very small number of students who study mathematics up to a higher level of education, for example at university level. The challenge to the educators is that they have to double their effort in teaching so as to overcome the dislike and negative attitudes towards mathematics that learners have acquired from their parents, relatives and school and, at the same time, they also have to deal with the abstract nature of the subject's content (Cornelius, 1982).

The researcher in this study's view is that special attention should be given to teaching strategies and to the topics that could be described as the core of mathematics, for example equations. Ideally, teaching strategies should include approaches that ensure the maximum participation of the learners (learner centered) as opposed to the traditional methods of teaching that are often teacher centered. However, approaches to teaching have been blamed for the failure in teaching and learning of some topics in mathematics. This means that some educators use approaches that are not relevant to a particular topic and in order to remedy this, they need to take into consideration not only the nature of the topic, but also the nature of the learners before applying a certain approach. It could be that unitary approaches should be abandoned in preference for teaching models, as such models take into consideration the content, the learning strategies, the learner and the arrangements that an educator puts into place to ensure that social interactions take place.

Research in the teaching and learning of mathematics (Cornelius, 1982; Zevenbergen, 2001; Cangelosi, 2003; Gadanidis, 1988; Polya, 1981; Nickerson, 1985) shows that a problem solving approach together with programmes that require the use of computers and calculators could serve to address the problem of high failure rates in mathematics; it could also remedy learners' lack of motivation and their dislike of mathematics. Hobden (1994) believes that there should be a change from traditional routine problems to problems that go beyond algorithms and put emphasis on understanding. This makes problem solving a necessary approach, as advocated by many mathematics education researchers. However, as noted by Booker (1998), many frameworks for problem solving in mathematics teaching and learning, such as those of Polya, are based on a linear model. This encourages the view of problem solving as a procedure that focuses mainly on the completion of the given task. Gadanidis (1988), at least, sees problem solving as the third dimension of his three dimensional model that emphasises the multidimensionality aspect of mathematics teaching and learning.

Many reports and articles have been written on problem solving as an approach to teaching mathematics that deepens learners' understanding of the subject (Cangelosi, 1992; Gadanidis, 1988; Cornelius, 1982). However, educators struggle to implement problem solving because the researchers do not indicate how educators should put it into practice; they only admire its effectiveness. For instance, there is a belief that problem solving provides an excellent opportunity to learners to develop concepts and during this process they use the previously gained knowledge (Polya, 1981; Schoenfeld, 1985). It also gives learners an opportunity for mathematical discovery and creativity (Gadanidis, 1988). According to Gadanidis (1988) problem solving is the third dimension of a mathematics teaching and learning model. Such a model is based on the assumption that mathematics teaching has three important dimensions or areas of emphasis. These are teaching of facts and skills, teaching for understanding and teaching for problem solving. These components are lacking in traditional methods of teaching, which implies that solely teaching problem solving might have certain shortcomings. It needs to be preceded by the other two dimensions. When the teaching of facts, skills and understanding is ignored, problem solving will not adequately address the problem of mathematics being a fearful subject. For this reason, Gadanidis believes that mathematics teaching needs to integrate all three dimensions in order for the approach to be holistic. Ausubel (1968) argues that such re-enforcement of the model's components results in a meaningful learning.

In mathematics teaching and learning, particularly in algebra, the main problem seems to lie with:

(a) Teaching methods that are not relevant to particular topics and learners. When educators prepare their lessons they do not take into consideration the nature of the learners and the topic. The method needs to cater for the majority of the learners in the classroom.

(b) The content of algebra, which seems to require a better understanding of structural conceptions, while educators tend to concentrate more on procedural conceptions, particularly on the elementary level. When learners proceed to upper grades, algebra becomes abstract to them.

(c) The kind of representations used during the teaching process. Some educators seem to be uncertain whether the focus of their mathematics teaching should be on procedural or structural conceptions or whether the emphasis should be on tabular, graphical and symbolic representations.

(d) The classroom settings that can enhance meaningful teaching and learning. For example whether the focus should be in the whole class teaching or it should be on group work. Furthermore if the group work is used the question arises: how big should the groups be to enhance teaching and learning?

According to the writer's view, procedural and structural conceptions of algebraic situations, such as equations, need to be nourished. The procedural conception is enhanced when learners are taught substitution, for example that $6x + 4x$ when $x = 4$ has a value given by $6(4) + 4(4) = 24 + 16 = 40$. The structural conception is enhanced if learners understand that $6x + 4x = 10x$. However in early algebra the lack of understanding the meaning of the equal sign (=) creates reluctance in learners to accept the statements like $6 + 5 = 10 + 1$. Consequently, the result is learners' failure to comprehend the difference between an equation and algebraic identity and thus equations become difficult to solve, which implies that problem solving can be successful provided that the learners attach meanings to what they learn. According to Ausubel (1968), meaning in learning is achieved through a good relationship between learning materials and the learner's cognitive structure. Furthermore, the literature reveals that technology could be seen as a mechanism to enhance problem solving. For example, Lee (1999:138) writes, "Besides enriching the content of discussion and the quality of the eventual product, computer-mediated communication enables students to negotiate meanings and to construct knowledge in a situational context that enhances meaningful collaboration through collaborative problem solving". The proponents of the usage of technology in the teaching and learning of mathematics believe that problem solving using "real problems" in a technological environment where learners interact with one another and with an educator might bring about a dramatic change in the way that learners view and esteem mathematics. According to Bell (1978), great success has been achieved in many of the countries where computers are used in the teaching and learning of mathematics. However, such success does not indicate the kind of representations to be used, the role of the educator, classroom organisation, that is, whether group work or individual work should be adopted during lesson presentation. Kaput (Grows, 1992: 530) argues that "all aspects of a complex idea cannot be adequately represented within a single notation system, and hence require multiple systems for their full expression". According to Kaput (1992), this implies that multiple, linked representations should be introduced in algebraic problem solving in a technological environment to enhance teaching and learning of algebra. The writer feels that this hypothesis needs to be tested.

One of the problematic areas that deserve special attention in mathematics teaching and learning involves the understanding of algebraic equations. Several studies have shown that difficulty is evident when learners are expected to translate the relationship expressed in natural language into a corresponding relationship expressed in algebraic equations and vice versa. For instance Rosnick and Clement (Nickerson,1985) reported that 37% of a group of 150 first year engineering students at the University of Massachusetts failed to write an equation to represent a particular relationship that was give in a natural language. This shows that there is a need to find a teaching approach that can address the common problems in algebra. Some of these problems and difficulties involve misconceptions that are rooted in the lack of understanding the meaning of symbols (letters), the meaning of the equal sign in equations, the shift from language representations to variables and vice versa. In other words, it means that there should be a shift away from approaches that focus on calculation processes instead of on structural aspects. While many researchers advocate the application of problem solving in mathematics, there are critical factors that need to be borne in mind. For instance, Schoenfeld (1985) emphasizes the fact that for learners to cope with problem solving they need to have relevant resources (previous knowledge) needed for a particular problem (heuristic strategies) and they should have control of the implementation of strategies and resources. This necessitates multidimensionality aspect in problem solving.

The points that have been mentioned in this text regarding an approach that enhances the teaching and learning of algebra prompted the writer to investigate the effects of involving aspects of multidimensionality in teaching algebraic equations in a problem-solving context.

The present study attempts to explore the effects of using a multidimensional approach as opposed to the traditional approach in teaching algebra. It furthermore attempts to explore the impact of using multiple representations for problem solving in a computer environment. These will help the writer to make recommendations for the use of a multidimensional approach and technology in the teaching and learning of mathematics. This might improve learners' understanding of mathematics and also create a love of the subject.

1.2 STATEMENT OF THE PROBLEM

1.2.1 Background to the statement

The American National Council of Teachers of Mathematics (NCTM) (Cornelius, 1982) made certain recommendations regarding mathematics teaching and learning that need to be considered. For instance, they recommended that problem solving should be the focus of school mathematics and that the curriculum needs to incorporate the use of computers. These recommendations, however, do not indicate how problem solving and the use of computers should be integrated in the teaching and learning of mathematics. The abstract nature of the subject seems to require teaching models that have a variety of components. In this study, the researcher refers to models that take into account different kinds of representations, classroom settings and learning media that are able to enhance learners' understanding of mathematics. This is in accordance with Gadanidis (1988), who suggests a model of teaching mathematics that views mathematics teaching and learning in a multi-dimensional perspective.

According to this model, mathematics teaching has three dimensions or areas of emphasis. These are: teaching of facts and skills, teaching for understanding and problem solving, which is regarded as the third dimension that needs to be integrated with other dimensions in mathematics teaching. Consideration of the other two dimensions in problem solving can lay a strong mathematics foundation that will enable learners to cope with the intellectual demands of problem solving. Problem solving teaches learners to solve problems in which solutions are not apparent and this might entail more than one concept and many strategies. As a result it becomes imperative to integrate other dimensions in problem solving and to think about representations and media that will drive the problem solving process. Many mathematics educationists, including Polya, Schoenfeld and others who advocate a problem solving approach in the teaching and learning of mathematics, do not clearly indicate the nature of the strategies that will ensure effective application of this approach.

1.2.2 Problem statement

Regarding the strategies in the usage of problem solving in mathematics teaching and learning, the researcher strongly believes that there are certain questions that need to be borne in mind, such as the following, for example:

(a) What kind of representations is essential for problem solving?
(b) How should the class be organised to allow effective use of problem solving?

(c) What could be the role of technology in mathematics problem solving?

The fast growing global awareness of technology has made many people believe that computer can be a powerful tool to enhance teaching and learning and also to create a positive attitude towards the subject of mathematics. According to Bell (1978), if a good educator uses the computer it can improve understanding of the instructions, promote learners' interest towards mathematics and thus promote learning. However the expertise of a good educator in relation to the methodology of teaching using a computer is not defined. The problem that is prevalent in school mathematics, particularly in word problems, equations and inequalities, is that of misconceptions and errors when learners are expected to translate the problem from a natural language into algebraic or symbolic form. To minimize such errors, Soloway, Lockhead and Clement make use of computer programming (Nickerson, 1985). It seems that the computer can be an effective medium in enhancing a learner's understanding of mathematics. However, there is no indication of how such computer-aided teaching can be used to achieve what the traditional way of teaching cannot achieve. To this end, the present study on teaching and learning of mathematics by using the computer attempts to address the following research questions:

1.2.2.1 What are the effects of a multi-dimensional approach assisted with the computer on algebra problem solving?

1.2.2.2 What effects do multiple representations in a computer environment have on mathematical problem solving?

1.2.2.3 What effect does computer assisted collaborative learning have on mathematical problem solving?

1.3 AIMS OF THE STUDY

1.3.1 To test the effects of a multi-dimensional approach using the computer in algebra problem solving.

1.3.2 To determine the effects that multiple representations in a computer environment have on mathematics problem solving.

1.3.3 To determine the effects of computer assisted collaborative learning on mathematics problem solving.

1.4 HYPOTHESES

The hypotheses of the study are as follows:

1.4.1 Hypothesis 1

The use of a multidimensional approach involving computers will influence problem solving in algebra.

1.4.2 Hypothesis 2

The use of multiple representations involving computers will influence problem solving in word problem translation.

1.4.3 Hypothesis 3

The use of computer assisted collaborative learning will influence problem solving in mathematics.

1.5 METHODS OF INVESTIGATION

1.5.1 Research Design

Research entailed a field study or field experiment. As a result the researcher had to visit the schools where the fieldwork was conducted.

1.5.2 Literature Review

This study makes use of and reviews literature concerning problem solving and the use of computers in mathematics teaching and learning. Primary as well as secondary sources are reviewed.

1.5.3 Study Sample

The sample of the study consists of grade eight learners who do mathematics in the selected schools. The schools are located in the Empangeni district of Northern KwaZulu-Natal. Random sampling was used to select the schools in which the fieldwork was conducted.

1.5.4 Instruments

An achievement test on algebra problem solving as well as a questionnaire used by the University of Stellenbosch was used as the measuring instruments. The researcher, the researcher's assistant and the mathematics educator in a particular school administered the instrument. The achievement test was divided into five sub-tests. For the purpose of this study, however, only four sub-tests were used. The question paper was designed in such a way that it provided spaces for the answers, so that the learners could write the answers directly in the spaces provided. The marking was done by the researcher, according to the method of marks allocation given in the memorandum. A t-test was used to measure the differences between the experimental group and the control group with regard to the effects of using computers in algebra problem solving.

1.6 DEFINITION OF TERMS

The terms used in this study are defined as follows in order to avoid confusion:

1.6.1 Multi-dimensional approach

In this study, multi-dimensional approach shall mean the model of teaching that assumes that mathematics teaching has three important dimensions or areas of emphasis, namely the following:

(a) The teaching of facts and skills

(b) Teaching for understanding

(c) Problem solving (third dimension)

This model suggests that if the first two dimensions are integrated with problem solving, problem solving will be more meaningful and effective to the learners.

1.6.2 Traditional approach

In this study, traditional approach shall mean the model of teaching that is teacher centered. In other words, where the teacher dominates the lesson and learners passively receive knowledge from the teacher. The focus of the learning in this approach is at the completion of the learning programme with little or no consideration of other factors that can create understanding of the subject.

1.6.3 Multiple representations

In this study, multiple representations shall mean the representation of a mathematical concept or idea using several notations, such as words, equations, tables, flow diagrams and graphs.

1.6.4 Collaborative learning

In this study, collaborative learning shall mean learning where learners work together, and discuss and share ideas and experiences about the content of the subject.

1.7 THE PLAN OF THE STUDY

The study is organized as follows:

1.7.1 CHAPTER ONE

Chapter one consists of the motivation for the study, statement of the problem, the aims of the study and the organisational plan for the layout of the whole presentation of the research process.

1.7.2 CHAPTER TWO

This chapter contains the theoretical framework on which the study is based. In the theoretical framework the models of mathematical teaching and learning that are relevant to the study and appropriate for improving mathematics learning are discussed. The discussion includes the extension of Gadanidis' model by including multiple representations in computer assisted problem solving. The ideal classroom setting (organisation) that allows problem solving to function effectively is also discussed in this chapter.

1.7.3 CHAPTER THREE

This chapter describes the methodology and the research design of the study. The procedures for collection of data and the selection of the participants and the data analysis plan are described in this chapter.

1.7.4 CHAPTER FOUR

This chapter is concerned with the analysis and the interpretation of data, the summary of data analysis and the conclusion.

1.7.5 CHAPTER FIVE

Chapter five comprises a discussion of the findings of the research study, the implications of the study to education, a generalisation of the study, the limitations of the study, recommendations and the conclusion.

CHAPTER TWO
LITERATURE REVIEW

2.1 THEORETICAL FRAMEWORK

A number of reports and articles have been written in attempts to describe the factors that contribute to the low achievement of learners in mathematics (Orton, 1987; Cornelius, 1982; Kieran, 1992; Zevenbergen, 2001). These studies outline causes of difficulties and problems in the teaching and learning of mathematics. Among the primary causes of difficulties in mathematics teaching and learning is, firstly, the language of instruction, particularly when it is not the learners' home language (Sibaya, Sibaya and Mugisha, 1996), and secondly, misconceptions resulting from the lack of understanding mathematical symbols. Some of the difficulties are related to the educators' approaches and strategies in teaching mathematics, and in their knowledge of content and their motivation (Mji & Makgato, 2006).

However, very few studies have seemingly addressed these problems successfully. This is more evident in South Africa where there has been no remarkable change regarding improvement in grade 12 mathematics results. One of the critical issues concerning poor performance in mathematics is the lack of links between that which is taught in elementary mathematics classes and in senior classes. This is, to certain extent, the direct results of the large number of under-qualified or unqualified educators who teach mathematics in overcrowded and unequipped classrooms. The heads of institutions are tempted to put the few qualified educators in senior classes, like grade 12, because the performance of the school is measured according to grade 12 results in South Africa and elsewhere. In this situation, under-qualified educators in high schools often teach the junior classes (grade 8- grade 10). As a result they fail to acquire the background that will enable them to cope with the demands of mathematics at higher level. This has been evident in the Third International Mathematics and Science Study (TIMMS) conducted in 1995 and 1999, where South Africa participated with other countries and it was reported that South African Grade 8 mathematics learners came last (Mji & Makgato, 2006). The Monitoring Learner Achievement (MLA) project, which assessed Grade 4 learners against a set of internationally defined numeracy and literacy competencies, also revealed that South Africa is rated last in numeracy compared to other African countries (DoE, 2001). This is further aggravated by the fact that even those who are considered as qualified mathematics educators tend to focus more on the completion of the syllabus with little or no effort applied to what has been learnt in solving mathematics-related problems. Maybe now that the Department of Education has adopted outcomes-based education (OBE) the application of mathematics in solving mathematical problems will improve. However, the main challenge to the Department of Education is to ensure that educators are well trained in order to implement this learner-centered system of education.

Some of the studies that have been conducted in other countries suggest that since meaningful learning occurs by involving learners in the teaching and learning process, the focus of mathematics teaching and learning should be on problem solving approaches (Polya, 1981; Schoenfeld, 1985; Gadanidis, 1988; Cangelosi, 2003; Ernest, 1991; Orton, 1987). A problem solving approach is based on the idea that subject should be made problematic during the teaching and learning process. It is however vital to note that here "problematic" is not used to mean to frustrate learners and to make the subject extremely difficult. It should be problematic in a sense that it allows learners to wonder why things are, to inquire, to search for solutions and to resolve incongruities (Hiebert *et al.,* 1996). While many mathematics education specialists agree that the problem solving approach can address the difficulties in teaching and learning of mathematics it is important to understand what the problem solving approach entails. Hiebert et al note that problem-based learning is not simply the addition of problem solving activities to otherwise discipline-centered curricula, but a way of conceiving of the curriculum which is centered around key problems in professional practice (Hiebert *et al.,* 1996:14). Problem based courses start with problems rather than with an exposition of disciplinary knowledge. If we intend adopting a problem solving approach in the teaching and learning of mathematics then we should encourage learners to problematise the subject. As a result, problem solving needs to incorporate other important components or dimensions of teaching and learning such as learning of facts and skills in order to lay a strong foundation for problem solving sessions. Furthermore, it is suggested that this approach must consider the medium in which learners learn mathematics as an important tool. This medium is also regarded as one of the dimensions that assist the problem solving process. As a result Steffe and Wiegel, (1994:113) has this to say: "the nature of the medium in which children learn mathematics *is essential* because the medium must not only support the construction of mathematical concepts and operations, it must also provide the possibility for creative expression of those concepts and operations in the pursuit of goals". This text therefore uses the computer as a medium of learning mathematics. The idea here is to examine the ability of a computer to allow a learner to explore, investigate and pose problems and flexibly represent situations in different forms that is in symbolic, graphical, tabular and so forth. There is a strong believe that this will try to give learners another view of mathematical concepts particularly algebraic concepts which can then enhance problem solving abilities.

2.2 THE EFFECTS OF A MULTIDIMENSIONAL APPROACH ON ACHIEVMENTS IN ALGEBRA

Traditionally mathematics teaching has been consisting of the teaching of facts, skills and principles that are based on algebraic problems with worked out examples in the textbook or by the teacher. In this kind of teaching and learning, learners are directed towards methods that the teacher and the textbook consider as essential, without any apparent understanding of what it actually is that leads to meaningful learning. In an attempt to address this, many researchers and educationists advocate the use of problem solving approaches but it seems that different educators conceive differently what the problem solving entails regarding its implementation. Those who might have understanding of problem solving approach may be they lack the appropriate strategies of its implementation. As a result this teaching approach needs to be given a particular attention that will enhance its effective application in teaching and learning of mathematics. It is however noted by Booker (1998) that many frameworks for problem solving are linear. For instance, Polya (1945) suggests problem solving technique with four stages that is, understanding the problem, devising a plan, carrying out a plan and looking back. Hadamard, (Orton, 1987:92) also suggests four stages in the solution of the problem, that is, preparation, incubation, illumination and verification. These frameworks are mainly concerned with the procedure leading to the completion of each step in the solution or task (Booker, 1998). In this regard, the researcher feels that the content of mathematics that will equip learners with skills essential to select relevant strategy in problem solving processes is not taken into consideration.

Gadanidis (1988) views mathematics teaching and learning in the light of three major areas of emphasis that he believes contributes to a holistic approach. For instance, he places teaching of facts and skills as the first dimension in his three dimensional model. This dimension motivates and create positive attitude of learners toward mathematics because it concentrates on standard textbook exercises that often allow a learner to experience success. Traditionally if learners are successful in these exercises the educator thinks that the objectives of the lesson have been achieved. However, Skemp (Gadanidis, 1988) says these learners fail to apply this in other problems that are beyond their class exercises.

The second important dimension is the teaching specifically for understanding where the focus is on the processes of the solution rather than the answer. Understanding is evident when learners can effectively apply factual principles and skills taught in the first dimension. In this regard mathematics becomes meaningful because the learners are taught to justify what ever solution they get in a particular problem. According to Gadanidis (1988) the first two dimensions lay a good foundation for problem solving which he regards as the third dimension that needs to be integrated with other components in the teaching and learning of mathematics. According to Gadanidis (1988) problem solving will be successful when learners attach meaning to their learning. Meaning in learning could be achieved by a good relationship between the learning material and the learner's cognitive structure (Ausubel, 1968), and this is unfortunately lacking in traditional approaches to the teaching of mathematics. Problem solving puts emphasis on the discovery of learning how to solve problems with no apparent focus on answers. For this reason, Orton (1987:92) argues that educators should instill a systematic approach to problem solving in learners. Possibly, the approaches used in problem solving should teach learners that doing mathematics is not only concerned with the application of problem solving procedures without understanding. It is about getting correct answers through reasoning about problems to be solved and managing them by using heuristics, control strategies and beliefs (Schoenfeld, 1985). In this context heuristics refers to the strategies and techniques that enable a learner to make progress even on unfamiliar problems. This includes the ability to interpret and represent a problem using suitable notation. According to Schoenfeld's viewpoint, a learner should be able to determine what heuristics are likely to get him closer to the solution (control strategies).

With this in mind the researcher sees Gadanidis' multi-dimensional model of teaching and learning as the one that can achieve the objectives of problem solving opposed to traditional models that are linear in nature. Gadanidis, however, does not consider a medium with which to facilitate the application of these dimensions; for this reason there is a need for a tool that can be used to maximize problem solving in mathematics. The reason for this is that the nature of problem solving is intellectually demanding. It has been noted by Kieran (Grows, 1992:390) that "secondary school students generally seem to have some knowledge of basic algebraic and geometric concepts and skills". However, the results of the mathematics assessment report on US students conducted by the National Assessment of Educational Progress (NAEP), indicated that students are often not able to apply this knowledge in problem solving situations. The students appear not to understand many of the structures underlying these mathematical concepts and skills. The researcher perceives this problem as prevalent in South Africa and elsewhere in Africa – and hence the need to address it in a South African context.

One approach has emphasized the learners' lack of understanding the meaning of the variables or letters (Kuchemann, 1978). Some of the common findings by Kieran (1992) and Booth (1990) reveal that some learners ignore the letter ("n" in this case) completely as in the following: $3 + n + 5 = 8$ and sometimes they associate letters with their corresponding numbers in the alphabetical list, such as that in the equation $p = 16$, this is so because p is the sixteenth letter of the alphabet. Learners also seem to lack the understanding of the meaning of equality in equations (Kieran, 1992). This is evident when learners do not see the equal sign as indicating equivalence in two expressions and instead see it as a symbol separating two expressions, as in this example (below) where they are required to find the value of x:

$2x + 3 = 18$: They write it as follows $2x + 3 = 18$

$$2x +3 -3 = 18$$

$$2x = 18$$

$$x = 9$$

Sfard (Kieran, 1992) ascribes this failure to the neglect of the procedural and structural conceptions in the teaching of algebraic expressions and equations which then minimizes chances of effective problem solving for learners. According to Hart (1982), the main findings of both the Concepts in the Secondary Mathematics and Science Project (CSMS) and the Strategies and Errors in the Secondary Mathematics Project (SESM) is that the majority of pupils take a naïve view of the use of letters in mathematics. As a result the writer believes that the problem solving approach alone may not be enough because mathematics is a language on its own. The procedural and structural perceptions of algebraic situations, understanding of the use of letters and equality have to be nourished by exposing learners to many different kinds of representations and technology seems to play an important role in achieving this.

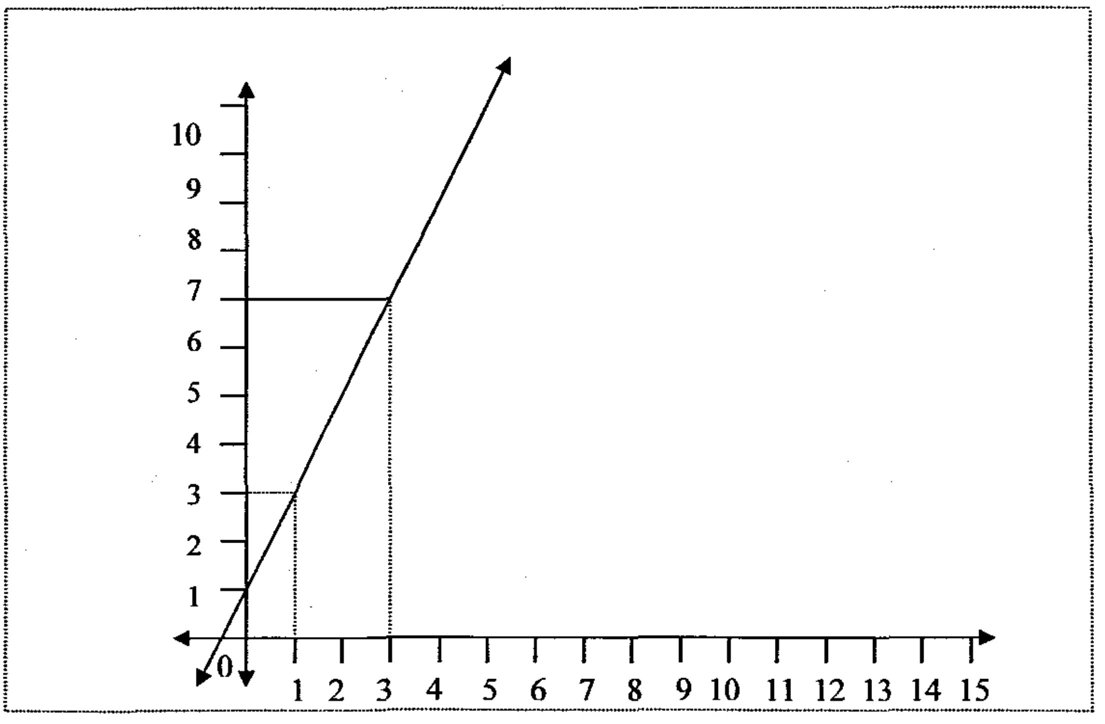
2.3 THE KINDS OF REPRESENTATIONS ESSENTIAL TO ENHANCE AN UNDERSTANDING OF ALGEBRAIC CONCEPTIONS

While it could be argued that the integration of problem solving with other components (multi-dimensional approach) can result in a substantial enhancement of algebraic conceptions, it seems that this model needs to be extended to state the kind of representations essential in problem solving in order to improve algebraic conceptions. As mentioned earlier on, learners' problems in algebra result from misconceptions, a lack of understanding the meaning of equality (=), from variables and failure to translate problems from natural language into equations or vice versa. Some of these difficulties are the direct result of teaching approaches that put emphasis on the calculation process rather than on structural aspects (Sajka, 2003; Sierpinska, 1992). These approaches encourage passive acceptance of the rules of calculations with no understanding and control of meaning conveyed by these rules (Sfard, 1994). This necessitates different representation systems that will enforce the understanding of the mathematical rules and the structural aspects in algebra.

According to Kaput (Grouws, 1992), the single notation system cannot adequately represent all aspects of a complex idea, hence multiple systems are required for the full expression of that idea. Kaput, (1989:167) has the following to say in this regard: "Individual learners use representation systems to structure their mental representations". For instance, in the case of functions in algebra, three representations can be used in the mathematisation of the phenomenon, namely: by forming an input-output correspondence of two quantities using numbers; using graphs and tables as linked representations of the situation, and thirdly, by using expressions (Yerushalmy, 2000). As an example of what Yerushalmy means by this, I suggest the following scenario: An educator wants to introduce functions and equations; he uses the flow diagram and give learners the input and output numbers and asks learners to guess the rule applied in the process of getting the output. For instance, if the input number is 2, the output number becomes 5; when the input is 3, the output is 7. They continue with this exercise until the learners are able to describe their generalisation of the process in words. They can say that "an input number is multiplied by 2, then add 1 to find the output". An educator helps them in writing this generalisation as an algebraic expression that represents the phenomenon, that is: $2x + 1 = 5$; $2x + 1 = 7$ and so forth, where x is an input number. This is also presented in tabular form as follows:

Input(x)	1	2	3	5	6	9	10
Output(y) y =2x+1	3	5	7	11	13	19	21

The same information is represented in the form of a graph on a Cartesian plane, as follows:



These representations represent one mathematical conception in different forms; as a result there is a strong belief that they re-enforce each other to enhance learners' understanding of the concept. The movement from one representation to the other is shown when, for instance, a graph of a situation is provided together with the table and a corresponding flow diagram in the manner indicated by Janvier, (1978).

Wegner and Kieran (1989:231) also point out that "algebra is the critical filter that prevents many students from pursuing mathematics beyond arithmetic". They also believe that the effect of different representation systems such as natural language, graphing, tabular data and alphanumeric symbolism need to be explored in algebra. In traditional approaches these representations are often not linked to represent the same mathematical entities. This implies that more attention needs to be given to the question of how learners use and coordinate multiple representations of fundamental concepts and procedures such as variable, equivalence, relation, inequality, solving equations and so forth.

As mentioned before, this study focuses on doing algebra in a computer environment, which implies that the representations are executed with software. However, Pimm (1995) cautions that learners who have over a long period of time become used to using software in doing algebra, tend to develop a dependency on the software – which might result in technology replacing the need for learners' understanding. Nevertheless, Yerushalmy's research findings are contrary to these speculations: he finds that, for high achievers, the software is useful immediately when available, and they can still perform well if it is taken away from them. He furthermore argues that students make use of linked representation for elaboration, paying attention to subtleties and nuances that would have eluded them otherwise (Yerushalmy, 2000:144). The effectiveness of these representations is enhanced by the use of the software, and this is unlikely to occur in traditional approaches to teaching.

2.4. THE EFFECTS OF COMPUTER-ASSISTED INSTRUCTION IN THE EACHING AND LEARNING OF ALGEBRA

Many researchers and educators believe that technology can play a vital role in enhancing the understanding of mathematical conceptions (McConnell, 1988; Heid, Sheets & Matras, 1990; Bell, 1978). One of the articles on this topic advises that the teaching of computer programming in classes could help pupils to understand certain mathematical concepts such as variables, operations on variables and functions (Hart, 1982). Several studies have been conducted with regard to the role of technology in the teaching and learning of algebra (Kaput, 1992; Fey, 1989; Senk, 1989; Kieran, 1989; Bell, 1978; Lee, 1999). The main focus of these studies has been the effect of computer-assisted instruction in the teaching of algebra. Bell (1978:429) notes, "Many mathematics teachers successfully use computers to enhance teaching and learning in many different ways".

As mentioned by Steffe and Wiegel (1994) regarding von Glasersfeld's principle of active learning, the intention here is not just to provide technical knowledge about mathematics learning, but to establish how this technical knowledge can be used in evolving constructivist models of mathematics teaching and learning. For instance, Fey (1989) found that the computer offers students an opportunity to learn effectively when learning is aided by multiple, linked representations of the abstract concepts and relations involved in expressions. According to Wagner and Kieran (1989), certain algebraic concepts, for example the notion of a variable, are more easily comprehended by learners with computer experience than one would expect in a traditional approach.

Many of these studies, however, have been conducted mainly in European countries, whereas the extent of computer usage in mathematics was determined by means of international surveys conducted as part of the original and repeated implementation of the Third International Mathematics and Science Study [TIMMS] in England, the United States, Singapore, Canada, Hong Kong and Korea, where a high degree of computer usage was reported among students in their mathematics learning (Ruthven and Hennessy, 2002). In South Africa and elsewhere in African countries, very little if any work has been done regarding teaching and learning in a computer environment.

As mentioned before, another factor that is central to the teaching of mathematical problem solving is language. Zevenbergen (2001) and Secada (1992) believe that language proficiency often correlates with mathematical achievements. More recently, there has been an increasing awareness of language and its impact on mathematics learning (Zevernbergen, 2001). This corresponds with a report by Rosnick and Clement, Kaput and Clement, Rosnick, Clement *et al.*, (Nickerson, 1985) that there are university first year engineering students who could not express the following relationship: "There are six times as many students as professors" as an algebraic equation. The reason is that the relationship is expressed in natural language. It implies that this problem is, to a large extent, due to learners who are taught mathematics through a second language. In this regard, Sibaya (1996:33) has the following to say: "Where black pupils come across mathematics which is taught in a second language, English, at school, the problem of learning mathematics is compounded". It is therefore important to note that underachievement by learners who are regarded as failures are sometimes the result of a mismatch between the learner's language and the language of the school, rather than the inability to do mathematics (Zevenbergen, 2001). To address this problem, Soloway, Lockhead and Clement (Clement & Sarama, 1996) used computer programming to minimize errors that often occur mostly when learners solve algebraic equations, even those translated from natural language. Their positive finding is confirmed by Noss (1988), who assigned a group of seven computer-experienced children structured and progressive mathematical task on ratio and proportion, both on and off-computer. Their performance showed that children successfully tackle the tasks in a computer environment whilst none of the same children given a pencil and paper ratio test produced the correct answer to items of the same depth and content. This exploratory study shows that computers provide the support that enables learners to explore and develop relationships that are beyond their grasp in traditional methods of teaching and learning.

As the content is enriched by multiple representations in computer learning, whereas it is hypothesized in text, this enables students to negotiate meanings and contrast knowledge, which enhances meaningful collaboration among the learners (Lee, 1999) – which is the essence of mathematical problem solving. As noted by Demana and Waits (1990:212), "Classroom instructional models that encourage students to be active partners in the learning process are the consequences of an approach that uses realistic and complicated representations". Computer-aided learning seems to be one of such approaches, as described by Demana and Waits (1990). A technology-based approach to the teaching and learning of mathematics was piloted and field-tested in a calculator and computer pre-calculus (C^2PC) project. In this project teachers used a technologically driven strategy where learners had one computer; they participated in interactive lecture demonstrations and in computer laboratories, where the setting for the guided discovery instructional model was put in place. Educators advise activities that are supportive and that lead to the discovery of important mathematics concepts (Demana & Waits, 1990:213). It is necessary to try these approaches in South African schools. It is, however, also important to note that one of the findings of the studies conducted in the United States regarding the use of computers in mathematics teaching, reveals that teachers who are successful in their teaching use both skill-focused software (drill and practice) and open-ended software (spreadsheets and mathematical games) (Ruthven and Hennessy, 2002).

The roles of both educators and learners seem to be challenging in computer assisted instruction. Nevertheless Heid, Sheets and Matras (1990) suggest that in the implementation of computer-based teaching and learning, the educators should technically assist the learners through collaboration and facilitation so that learners can see for themselves when the solution is wrong and where they can correct it themselves at the same time. This implies that mathematics educators have to liaise with computer educators (Cornelius, 1982: 36-57) to ensure effective assistance. The multi-dimensional model of teaching and learning is adopted so as to address the objectives of this study. This model extends Gadanidis's three-dimensional approach by harnessing multiple representations and collaborative learning in a computer environment within the context of South Africa.

2.5 THE EFFECTS OF COLLABORATIVE LEARNING IN MATHEMATICS PROBLEM SOLVING

Allowing learners to work in small groups during problem solving sessions enhances collaboration. According to Johnson and Maruyame (1983), the motivational component of small group work can promote students' mastery of mathematical skills and concepts (Good, Mulryan & McCaslin, 1992). Schoenfeld also advocates small group participation. He believes that group decision-making provokes articulation through discussion and argumentation of certain issues, and this encourages the development of the meta-cognitive skills involved in the problem solving process.

Piaget, Vygotsky and other literature that is discussed in the text largely inform the collaborative learning model, which presents teaching and learning in terms of a constructivism perspective. According to Piaget and Vygotsky (Moll, 2002:17), the learners actively construct knowledge by unifying and transforming innate and environmental processes into new forms of knowledge. Steffe and

Wiegel (1994:111) remark as follows in this regard: "Knowledge is not passively received but actively built up by cognizing the subject". This means that no knowledge is constructed if learners have not mastered the subject; they only accept rules and procedures without understanding them. According to the constructivist view of learning, the learners construct new knowledge with the help of a more knowledgeable person. According to this view, the model perceives the educator as the facilitator whose presence is necessary so as to create situations conducive to discovery learning, where several learning strategies are used as opposed to the traditional methods, with educator expository teaching and learning. The constructivist approach enables the learners to construct concepts and mathematical ideas on their own. As a result an educator can detect learners' misconceptions and misinterpretations about the subject (Sibaya & Mugisha, 1996). Although learners, to some extent, are given opportunities to individually and independently construct their own pathways that lead to the understanding of algebra, Piaget's collaborative peer learning is the dominant teaching and learning strategy of this model. This is in accordance with mathematics teaching and learning that suggests that learners should be encouraged to exchange viewpoints among themselves (Kamii, 1990).

Cooperation among learners or between learners and educator signifies the importance of language and multiple representations because it is through language that social and mathematical experiences are internalized (Vygotsky, 1978:151).

However, mathematics is a language on its own, which makes algebra to be seen as challenging and difficult to understand. For this reason there is need for a tool that will mediate the process and that will ensure that a learner understands algebra. The computer is used as the medium that supports learners' thinking by posing challenging questions to enforce construction of new knowledge. This strategy also teaches learners how to think mathematically and how to use mathematical language to create, interpret and express their own mathematical meanings as well as to interpret the mathematical language of others.

2.6 CONCLUSION

In conclusion it is important to note that the literature review indicates various studies that maintain that problem solving has the potential of improving mathematics learning. It is also important to take into consideration the multidimensional perspective of problem solving, rather than to see it as the process of mastering the sequence of steps that lead to the completion of the given task.

It is furthermore evident from the literature that mathematics learning becomes more meaningful when linked multiple representations are used to express the same mathematical concept or aspects of complex idea (Kaput, 1992). The computer facilitates the use of these representations. The literature reviewed also indicates that the computer enhances collaboration amongst learners. For effective collaborative and interactive learning, learners need to be divided into small groups that will allow discussions and negotiation of meanings. Since most of the studies have been conducted in European countries it is necessary to also test them in South Africa. The research design and methodology are discussed in chapter 3.

CHAPTER THREE
RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This chapter focuses on the research design and methodology used in collecting data for the study, the research instruments and the processing of the collected data. The main objective of the study is to determine the effects of using the computer in algebra problem solving. In order to achieve this objective, the study examines the effects of a multi-dimensional approach and the use of multiple representations and collaboration in problem solving.

3.2 RESEARCH DESIGN

In order to address the questions and to achieve the aims of the research as outlined in the text, the study makes use of both quantitative and qualitative methods of data analysis. The research design used in this study is experimental and descriptive. The descriptive design interprets and describes learners' behaviour, attitudes and experiences in mathematical problem solving in a computer environment. It furthermore describes a classroom setting that can facilitate collaboration among learners and the role of the educator in computer assisted problem solving. The experimental design is intended to determine the effects of using computers, multiple representations and collaboration in mathematical problem solving.

The choice of the research methodology was influenced by a number of factors. It is the contention of the researcher that methods used in a combination complement one another so that different facets of the phenomenon become noticeable. According to Khan (2000) the researcher, in this way, is able to build a complex, holistic picture of the problem by analysing words, reporting the detailed views of respondents and by conducting the study in a natural setting. It is for this reason that a combination of two methods of data collection (also called triangulation) was used in this study.

In many studies mathematical problem-solving abilities have been measured solely by means of the scores that the learners obtain in problem solving tests (quantitative data). For this particular study it was found necessary to combine quantitative and qualitative approaches in the analysis of problem solving behaviour. As noted by Merriam (Creswell, 1994), the idea is to understand all the processes and to describe factors influencing mathematics achievements and performance of South African learners, and to ascertain the effects of technology in mathematical problem solving. To this end, while the study considers the quantitative aspects, it also takes into account the description and interpretation of the reasons why learners perform the way that they do in achievement tests (qualitative aspects).

3.3 SAMPLE

Three schools in the Empangeni district were randomly chosen for this study with grade eight learners only in each of these schools as the participants in the experiment. Each of these schools had four grade eight classes, of which two classes per school were taken as the experimental group and the other two as the control group. Hence, there were six experimental groups and six control groups in the three schools. The total number of participants was 588, out of which 336 formed the experimental group and 252 the control group. Random selection was used in order to avoid bias.

According to Fraenkel and Wallen (Myeza, 1998), "A simple random sampling is one in which each and every member of the population has an equal chance of being selected. It is the best way yet devised by human beings for obtaining a sample that is representative of the population from which it has been selected". Nyuswa (2003) defines a sample as a small portion of the total set of objects, events or persons, which together comprise subjects of the study. The schools with computers in the area were given numbers and the numbers were written on pieces of papers. These papers were put together and shaken and thereafter three papers were picked up representing the selected schools (Myeza, 1998). This technique is called the fishbowl technique.

The schools used in this study serve learners from townships, from the informal settlements near the townships as well as learners from rural areas. According to the teachers' registers, the average number of learners in a class was 49 at the time of the study. The language of instruction at these schools is English, which is a second language to these learners. The schools do not have rigid selection criteria for admission of learners, apart from a pass in the previous grade. Most of these learners do not have a background of computer usage, consequently they do algebra and computer practice at the same time.

3.4 RESEARCH INSTRUMENTS

3.4.1 Description of the instruments

The instruments used in this study were an achievement test and a questionnaire, both designed by Olivier of the University of Stellenbosch in 2005. Such a combination of two methods of data collection as used in this study is called triangulation – a method that helps the researcher to see a phenomenon in different ways, thus giving him/her a better understanding of it. The questions in the achievement tests and the questionnaire used in this study were rearranged according to the aims of the study, although the wording and content of the questions remained as the University of Stellenbosch designed them originally. In other words, the instruments were not adapted to suit this study. The achievement test had five sub-tests, which were divided in accordance with the aims of the study.

However, for this study, only four sub-tests were used. Sub-test 1 is based on algebraic and arithmetic reasoning, sub-test 2 is concerned with word problem translation, and sub-test 3 tests knowledge of the concepts “variable” and “equality.” Learners are given substitution problems that lead to the formation of tables. Sub-test 4 is based on simple geometry word problems. Learners use formulas to calculate the dimensions of the geometric figure. This requires knowledge of manipulation of the formula and the substitution. The achievement test was generally designed to test learners’ notion of algebraic processes contained in the solutions of simple algebraic equations in one variable. These equations were given to the participants to solve, using intuitive, trial-and-improvement and formal methods (Kieran, 1992).

The questionnaire consisted of questions that require learners to compare their learning experiences while using the computer and when the computer is not used. It should be noted that the questionnaire was only used on the experimental group. The questionnaire furthermore required the learners to explain and describe the effects of computer-usage in problem solving. The questionnaire used because it permits anonymity, which increases the chances of genuine responses by respondents, reflecting their attitudes, feelings, opinions or perceptions (Pillay, 2005). Mahlangu (1997) also supports the use of a questionnaire because he believes that questionnaires are completed without external influences and because they are efficient and practical (Nyawuza, 2004). The questionnaire used in this study has three sections. Section A is based on the role of the computer in the teaching and learning of mathematics. For example, the learner is asked different questions based on how she/he solved problems in mathematics before she/he was introduced to Excel. Section C focuses on the role of collaboration in learning mathematics. For example, these questions require a learner to explain how he/she works with his/her fellow classmates when solving mathematics problems while using a computer. Section B determines the role of multiple representations in learning mathematics. For example, the questions in this section require a learner to explain how the use of flow diagrams, tables, graphs, equations and formulas is important to him/her.

As mentioned before, language is one of the factors that contribute to poor achievements in mathematics. Learners would have to express themselves in their mother tongues in order to state their arguments properly in the questionnaire. For this reason the questionnaire was translated from English into the learners' first languages so as to allow them to express themselves freely and efficiently when describing their experiences in learning mathematics using a computer. This notion is also supported by Khan (2000), who maintains that, in qualitative research, the language of the subjects is important.

3.4.2 The relationship between the aims of the study and the instruments

The aims of the study, as highlighted in chapter one, are stated below together with the items in the instrument that were used to measure each aim. The aims are as follows:

(i) Aim number one:

To test the effects of a multidimensional approach using a computer in solving algebra problems

This aim was measured by means of an achievement test and a questionnaire. The achievement test contained questions based on algebraic and arithmetic reasoning (Annexure A). The achievement test was designed in such a way that it covered the assessment of facts and skills, understanding and problem solving skills (Gadanidis, 1988). It was hoped that the participants would perform better in problem solving by using a computer if they had learnt mathematics facts and skills as well as learning for understanding. For instance, the effects of a multidimensional approach in problem solving were assessed by the following kinds of questions: "Sipho thinks of a secret number. He then multiplies the number by 7, then subtracts 12, giving the answer of 100".

(a) If his secret number is k, write an equation to show the process

(b) Draw a flow diagram to show the process

(c) What is Sipho's secret number?

Section A in the questionnaire is based on questions that require learners to explain how the computer helps them to understand mathematics and how they feel about using computers in problem solving (Annexure B).

(ii) Aim number two:

To determine the effects that multiple representations in a computer environment have on mathematics problem solving.

This aim was measured by means of both instruments, that is, by an achievement test on teaching and learning of algebra and by means of a questionnaire. The achievement test requires learners to determine whether two expressions are equal or unequal. For example, learners could be given: "Which is bigger 2n or n + 2?" (Annexure A). Learners should show this by using substitution, a table of values and/or graphs to find the values of "n" which can make the two expressions equal or the other expression to be bigger than its counterpart. Section C, items 9-10 in the questionnaire is intended to determine the roles of the flow diagrams, tables, graphs, equations and formulas in mathematic learning (Annexure B).

(iii) Aim number three

To find out the effects of collaborative learning using computer assisted instruction in mathematics problem solving.

This aim was measured by means of achievement tests number three and number four with questions based on substitution and word-based geometry problems respectively (Annexure B). It was also measured by means of a questionnaire. The questionnaire consisted of questions that seek an understanding of how learners work in groups to solve mathematics problems through computer-assisted instructions. Section B, items 5-8 in the questionnaire focuses on the role of computer mediated collaborative learning in mathematics. Learners had to explain how computer-assisted collaboration affected their mathematics learning (Annexure B).

3.4.3 Validity and Reliability

The study is considered to be valid if its findings are applicable in reality and if one can allow generalisation. For example, validity could be internal or external. Internal validity refers to the extent to which the findings fit in with the reality. External validity refers to the "generalisability" of the study to other situations (Stott, 2002). The instruments used in this study were not standardised; they merely consisted of a test and questionnaire, so there was no information available regarding the validity and reliability of the instruments (Annexure D). However, to ensure the trustworthiness of the study, learners were given the questionnaires and requested to respond to them. When they had finished, the learners were asked to return them to the researcher. This would avoid a situation where a learner could discuss or share information with his/her classmates, which might jeopardize the trustworthiness of responses.

The test was designed in such a way that the question paper also provided the necessary space for filling in of answers. This ensured that learners who started writing late would not see the questions before the paper was written because the questions containing answers were returned to the researcher immediately after they had finished. To ensure that results of the achievement test were a true reflection of the learners' performance, they were given enough time to finish writing the achievement test.

3.4.4 METHOD OF SCORING

3.4.1 Scoring Procedure

The three aims of the study were addressed by the questionnaire and the achievement test. The achievement test was intended to determine the findings of the research in terms of the scores obtained by the learners and for this reason the test was divided into five subtests with different totals. For instance, the highest possible score in subtest 1 is 45 (HS = 45). In subtest 2 the highest score (HS) is 5; in subtest 3 the highest score (HS) is 6; the highest score in subtest 4 is 5, and in subtest 5 the highest score is 12.

3.4.2 Interpretation of responses to the questionnaire

In the qualitative data, similar responses to the same item were grouped together in each section in order to facilitate a search for response trends. The responses that contain the common idea were tallied and recorded in a frequency table. For example, in section A all answers that indicated that a learner fully supported the use of the computer in problem solving were grouped together to give the frequency, which was then expressed as a percentage. The same procedure was followed in section B and C of the questionnaire.

The responses to the questionnaire were interpreted as follows:

Section A: A higher frequency of positive responses would indicate that computer usage in teaching and learning of algebraic problem solving will have positive effects, while a higher frequency of negative responses would indicate that computer usage in mathematics learning and problem solving will have negative effects.

Section B: A higher frequency of positive responses would indicate that collaboration amongst computer-using learners is essential in mathematics learning, while a higher frequency of negative responses would indicate that collaboration aided by computer learning of mathematics will have a negative effect or will not improve mathematics learning.

Section C: A higher frequency of positive responses would indicate that multiple-representations play an important role in effective computer-aided learning of mathematics while a higher frequency of negative responses will indicate that multiple representations will not improve learning of mathematics.

3.4.3 Interpretation of the achievement test results

The scoring for the achievement test was quantitative in nature and the learners' marks were for this reason summed up in items of each sub-test and divided by the number of learners who wrote in that group in order to find the averages and standard deviation in both experimental and control group. As the main aim of the study is to compare the experimental and control group with regard to performance, the average for each sub-test written by the experimental group and control group was compared. Higher averages were interpreted as being in support of the hypothesis, while lower averages were regarded as proving the opposite.

3.5 DATA ANALYSIS

In this study, a data analysis was done for each aim. Two approaches were used in data analysis: the t-test was used to determine the difference between the mean scores of the experimental and control groups, while, for the qualitative analysis the frequency of the responses in the questionnaire was also used to determine the extent to which the computer created and promoted a positive attitude among the learners towards mathematics.

The t-test was chosen because it is the statistical technique used to see whether the difference between the mean scores of two groups is significant or not (Fraenkel & Wallen, 1991). In each subtest the marks for all the learners in both the experimental and control groups were added together in order to calculate both mean and standard deviations. The means for the experimental and the control groups were compared and the critical level of significance in differences was taken to be 0.01 and/or 0.05 (Frankfort, Nachmias, 1992; Gray, 2004).

In an analysis of the data obtained through the questionnaire, the responses were categorised according to the ideas they contained. For instance, responses with a common idea were put together and tallied to determine the frequency of the particular response in each question. Van den Aardeweg and Van den Aardeweg (1988) support the use of frequency tables as a useful tool in informing impressions about the distribution of data (Pillay, 2005). The total number of responses that indicated that the use of computers in algebra enhanced understanding of algebra and created a positive attitude towards mathematics was compared with the total number of responses that indicated that the computer couldn't improve the teaching and learning of mathematics. The high frequency of positive responses compared to negative responses would indicate that learners feel that the computer is a useful tool in problem solving and a low frequency would indicate the opposite.

3.6 PROCEDURES AND ADMINISTRATION OF THE RESEARCH INSTRUMENT AND CONTROL OF CONFOUNDING VARIABLES

The experimental class was divided into small groups and all learners were given an equal opportunity to solve mathematical problems using the computer. In the control group learners were seldom in groups and they solved mathematics problems without using the computer.

The following problem is an example of one of the problems that learners had to solve by using the computer. Bennie speaks algebra: "I take my secret number and add 5 to it------. Then multiply the answer by 12-----. Then my answer is 324. Can you find Bennie's secret number?" The computer tells learners to write an equation that describes the statement and to solve it using the trial-and-error method. If his number is a secret, then: (secret + 5) x 12 = 324. The learners use the computer to substitute different values for the secret number. The computer at the same time tells them whether the answer is correct or incorrect. In this example the computer teaches the learners to translate the statement from natural language into mathematical language and it also enables them to discover the rule in solving this kind of problem, even in the absence of the computer. The control group solved this problem using the traditional methods, where they only got help from an educator.

During the fieldwork of the study the learners in the experimental class were grouped proportionally to the number of computers available. Ideally a maximum of five learners were allocated per computer. The study focused on activities that lead to the solution of equations. The reason for selecting grade eight (8) is that the researcher was interested in a grade where the teaching of most of algebraic concepts begins. For instance, the concepts of variable, expression and algebraic equations are often introduced at this level.

The research assistant and the mathematics educators in the selected schools helped the researcher to teach and to administer the two instruments, namely the questionnaire and the achievement test. The fieldwork was carried out in February and March 2007, followed by assessment in April 2007. The learners were first given the questionnaire and then followed by the achievement test. However the questionnaire was only given to experimental groups because they used computers, while the achievement test was given to both experimental and control groups. The questionnaire and achievement test were administered by the researcher, research assistant and mathematics educators.

The instructions for the achievement test and questionnaire emphasised the importance of these exercises in the following way:

"You are participating in research on improving the teaching and learning of Algebra. So it is important that you *explain your reasoning in writing* and try your best in *each* question".

The following particulars with regard to each learner had to be filled in on the answer sheet:

Name of the school:
Date:
Grade and Group:

3.7 CONCLUSION

This chapter focussed on the research design and methodology of the study. The experimental and interpretive nature of the study necessitated both qualitative and quantitative approaches. For this reason, a questionnaire and achievement tests were used. The instruments were divided into sub-questions or subtests according to the objectives of the study. The collected data is analysed, interpreted and discussed in chapter four.

CHAPTER FOUR
PRESENTATIONS AND DATA ANALYSIS

4.1 INTRODUCTION

This chapter presents and analyses the data, which is based on information collected from three secondary schools. The respondents were learners in grade eight classes and the study set out to investigate whether the use of computers could enhance their problem solving skills in algebra.

In this study two perspectives of data interpretation were used, namely a comparison between the attainments of the experimental group and the control group, and a statistical test, which was used to determine the difference between the experimental group and the control group with regard to their performance in algebra. A questionnaire was used in order to take account of the learners' views about the use of computers in algebra problem solving. As mentioned before, the data obtained was reduced into categories in accordance to Nisbet and Entwistle (1970), who believe that the process of qualitative analysis and discussion is based on the reduction and interpretation of data (Pillay, 2005).

4.2 DATA ANALYSIS

4.2.1 Reiteration of hypothesis number one

The use of a multidimensional approach involving the computer will influence problem solving in mathematics.

The hypothesis was tested by using a t-test to compare the means (average) of the experimental group and the control group in the achievement test. The experimental group was taught to solve arithmetic and algebraic reasoning problems with the aid of a computer, while the control group was taught using traditional methods of teaching. Learners were given activities that focussed on the learning of facts and skills, followed by activities focused specifically on understanding. This focus of the activity is therefore on problem solving (third dimension). These three components were taken into consideration, while assuming that before learners can solve problems they should have learnt basic skills. Apart from this, they should also have an understanding of mathematics conceptions and rules. The success of problem solving is to an extent dependent on the other components that are referred to as the dimensions of mathematics learning. The t-test was used to compare two means to determine the probability that the difference between the means is a real difference rather than a chance difference (Tuckman, 1988).

Table 4.1 **The relationship between the achievements of the experimental and control groups in test 1: Algebraic and arithmetic reasoning (problem solving). [N=588]**

GROUPS	N	df	MEANS	SD	t	p
Experimental	336	586	2.60	2.47	9.22	.000
Control	252		.90	1.55		

The calculated t-value (9.22) is greater than both of the tabled values 1.960 (5 percent) and 2.576 (1 percent) as read off from table II (Tuckman, 1988). As a result, a null hypothesis can be rejected at both levels of significance ($p < .000$). This allows us to say with confidence that a multidimensional approach aided by the computer in teaching and learning influences problem solving in mathematics.

Table 4.2 **Learners' perceptions about the use of the computer in problem solving**

Can you tell how you solved mathematics problems before you were introduced to the use of the computer?

Responses	positive	negative	vague
Frequency	65	09	40
Percent %	57	08	35

The result from the questionnaire showed that the majority of the learners viewed the computer as an important tool that facilitates their mathematics learning because it guides them and gives them instant feedback. A most common statement made by the learners in the questionnaire was: *"Before I was introduced to the computer it was not easy to solve algebra problems but now I work well because the computer facilitates my work by giving instant feedback"*. The dimensions that have been put forward as the important components of mathematics teaching and learning become more effective in the presence of the computer because it improves understanding of mathematics concepts and instructions. About 66% of the learners remarked in the following vein: *"The computer has improved my understanding of mathematics instruction and thus my understanding of mathematics is better"*. This indicates the importance of the computer in complementing the multidimensional approach. The data provides reasons why the experimental group outperformed the control group. The intellectually demanding nature of problem solving seems to necessitate this dimensionality aspect of mathematics teaching, which finds best expression in a computer environment that is used to motivate learners. Statements from learners support the hypothesis that the use of a multidimensional approach involving the computer will influence problem solving.

4.2.2 Re-iteration of hypothesis number two

The use of multiple representations involving computers will influence problem solving in word problem translation.

This hypothesis was tested by a t-test, which is a statistical test that allows comparison of the means of the experimental and control groups (Tuckman, 1988). When multiple representations are used in mathematics, a mathematical concept or idea is expressed in words, flow diagrams, equations, tables and graphs. In the classes, the experimental group made use of the computer to do representations of mathematical concepts, while the control group did not use a computer. The data obtained by means of the questionnaire was analysed in order to establish the effects of using representations in computer problem solving.

Table 4.3 **Comparison of the performance of the experimental and control groups in word problem translation. [N=577]**

GROUPS	N	df	MEANS	SD	t	p
Experimental	336	575	1.21	1.0	15.52	.000
Control	241		.14	.34		

The calculated t-value (15.52) is greater than both of the tabled values 1,960 (5 percent) and 2,576 (1 percent) read off from table II (Tuckman, 1988). Therefore the null hypothesis is rejected at both levels of significance. We can therefore confidently say that multiple representations in a computer environment influence problem solving in word problem translation ($p < .000$). The experimental group outperformed the control group in this test. It was apparent from the table that translating a mathematical statement from natural language into algebraic language (symbolic form) is improved when using a computer.

Table 4.4 **Learners' perceptions about the use of multiple representations in algebra problem solving**

Explain whether each of the following is useful or not useful to you when learning algebra

Responses	positive	negative	vague
Frequency	132	06	90
Percent %	57	03	40

The data obtained from the questionnaire reveal that the majority of the learners believed that the use of multiple representations in a computer environment improved understanding of mathematical conceptions. For example, a high frequency of responses basically reiterate the following statement: "*My understanding of mathematics conceptions is improved by representing one conception using different methods such as words, tables, graphs, flow-diagrams and equations.*" It was, however, remarkable that some learners in the class during the fieldwork treated these representations in isolation from one another instead of using these them to represent one mathematical entity. Nevertheless there was a significant difference between the frequency of positive and negative responses.

4.2.3 Re-iteration of hypothesis number three

The use of computer assisted collaborative learning will influence problem solving in mathematics

This hypothesis was tested by the use of a t-test in order to compare the mean scores of the experimental and control groups (Tuckman, 1988). During the fieldwork learners in both experimental and control groups were working in small groups. In the control group, learners worked in the traditional way, using an educator as a source of knowledge. In these groups the focus was on substitution problems and solving of equations, which were intended to create an understanding of the differences between equations and identities and the differences between procedural and structural conceptions.

The learners were also given a word-based geometry problem to solve in their different groups, where they constructed geometric figures according to the given instructions. From these figures they derived general formulae to calculate area, perimeter and the dimensions of the figure and also to change the subject of the formula. In doing these activities the experimental group used a computer, while control group had no computer. Two sub-tests were given to assess the different groups' performance during collaborative problem solving in mathematics learning. One test was based on substitution problems and the other one was based on word-based geometry problems.

Table 4.5 **The relationship between the achievements of the experimental and control groups in test 3: (substitution problems) [N=588]**

GROUPS	N	df	MEANS	SD	t	p
Experimental	336	586	2.81	1.65	7.36	.000
Control	252		1.70	1.90		

The calculated t-value (7.36) is greater than both of the tabled values 1,960 (5 percent) and 2,576 (1 percent) as read off from table II (Tuckman, 1988). The null hypothesis is rejected at both levels of significance ($p < .000$). As a result we can ascertain that collaborative learning in a computer environment influences problem solving.

Table 4.6 **The relationship between the achievements of *experimental and control groups in test 4:* (geometry word problems) [N=588]**

GROUPS	N	df	MEANS	SD	t	p
Experimental	336	586	.02	.15	2.48	.014
Control	252		.00	.00		

The calculated t-value (2.48) is greater than 1,960 (5 percent) and less than 2.576 (1 percent) as read off from table II (Tuckman, 1988). The calculated t-value of 2.48 is not significant at 1 percent (1%). Therefore the null hypothesis is only rejected at 1,960 (5 percent) level of significance ($p < .014$). As a result we can say that collaborative learning in a computer environment influences problem solving in mathematics.

Table 4.7 **Learners' perceptions about collaborative learning**

Can you explain how you worked in groups? Could you solve many problems when working individually?			
Responses	positive	negative	vague
Frequency	85	10	19
Percentage	75	09	17

The data obtained by means of the questionnaire revealed that learners were committed when they were working in small groups with the computer. The majority of the learners said that they worked very well in groups because they discussed the problem and also explained to one another while also getting feedback from the computer. The learners saw the educator as a facilitator. As a result most of the learners' statements in the questionnaires were similar to this one, which is quoted as an example: *"When all group members have difficulty, the educator intervenes by giving explanations"*.

This is in accordance with constructivism advocated by mathematics education researchers (Moll, 2002; Lee, 1999; Kamii, 1990; Ernest, 1991). Furthermore the majority of the learners said that they could not solve many problems individually. This implies that learners benefit much from group work and this is further activated by the computer.

In a quantitative analysis it is often important to calculate effect sizes in order to compare the magnitude of the effect of the experimental treatments from one experiment to another (Thalheimer & Cook, 2002). As a result the tables of quantitative analysis are collapsed into one table that shows effect sizes for experimental treatment as follows:

Word problems translation: A
Algebraic and arithmetic reasoning: B
Substitution problems: C
Geometry word problems: D

Table 4.8 Cohen's d effect sizes for treatment groups

Grouping	X_1	N	X_2	N	S_{pooled}	Cohen's d
A	1.21	336	.14	241	1.00	1.07***
B	2.60	336	.90	252	2.20	.8***
C	2.81	336	1.70	252	1.76	.6**
D	.20	336	.00	252	.113	.2*

.2 small effect* .5 moderate effect** .8 large effect***

The effect of size on treatment is arranged in an ascending order of magnitude according to Cohen's d values. The use of computers had a greater impact on problems related to word problem translation. The use of computers also had a greater impact on algebraic and arithmetic reasoning. Furthermore, the use of computers had a moderate impact on problems related to substitution and it had a small effect on problems related to geometry word problems.

4.3 CONCLUSION

The focus of this study has been on the analysis and the interpretation of data obtained in three secondary schools where the participants were grade eight learners doing algebra while using the computer. The data obtained enabled the study to determine possible ways in which computer-assisted problem solving could be used in order to achieve good mathematics results or to lay a strong mathematics foundation at grade eight level for learners.

The findings of the study together with its implications, limitations and recommendations are discussed in chapter five.

CHAPTER FIVE

DISCUSSION OF FINDINGS, IMPLICATIONS, LIMITATIONS, RECOMMENDATIONS AND CONCLUSION.

5.1 DISCUSSION OF FINDINGS OF THE STUDY

5.1.1 Findings regarding the use of a multidimensional approach involving the use of the computer in algebra problem solving

In this study it has been found that the use of a multi-dimensional approach in a computer environment is likely to yield better results in problem solving than the use of the traditional approach in the teaching and learning of mathematics. For this reason, the findings of the present study support Gadanidis' findings (1988) that problem solving should be integrated with other components such as the teaching of facts and skills and teaching specifically for understanding. However, the present study went beyond Gadanidis' dimensions by taking into consideration the effects of a medium, such as a computer, multiple representations and collaborative learning in problem solving. The findings also support the theories reported in Sibaya and Sibaya (2004), namely that learners who use computers for interactive problem solving achieve better results in examinations and assignments than those learners who do not use computers. The present findings also support Bell, (1978) who concluded that in countries where the computer is used in the teaching and learning of mathematics, there has been an impressive success rate.

A learner who lacks the understanding of the foundational concepts will find it very difficult to cope with problem solving processes in mathematics. It has been found in the present study that learners who use computers more easily grasp these concepts than those who use the traditional method of learning mathematics. This is in accordance with the findings of Harskamp and Suhre (2004). These researchers found that students who had used computer programmes improved more in problem solving than did students who were not using computers.

5.1.2 Findings regarding the use of multiple representations in problem solving with the aid of the computer in word problems translation

The present study has shown that multiple representations in a computer environment improve learners' understanding of algebra. This became evident, as the experimental group outperformed the control group in word problems translation. This supports the belief that a complex mathematical idea cannot be expressed adequately with only one kind of representation (Kaput, 1992). Kaput (1992) further maintains that multiple, linked representations should be introduced in problem solving in a technological environment so as to enhance the learners' understanding of algebra. The present findings indicated that the majority of learners who used the computer for multiple representations were more successful than those who did not use the computer in translating the problem given in words into an algebraic equations. They were also more successful in representing the relationship between two variables using tables and a flow diagram to show the formulation of the equation and to solve the equation. These are compelling reasons for representing mathematics concepts in more than one form in the teaching and learning process. The findings reveal that translating a mathematical statement from a natural language into an algebraic language is one of the problematic areas in the teaching and learning of algebra. Carpenter and Moser (Kieran, 1992) maintain that elementary school children hardly ever write equations or expressions to represent arithmetic problems. Learners tend to use direct translation, which then necessitates multiple representations in a computer environment. For instance, one of the algebraic problems that were given to the learners during the fieldwork was: "Which is larger: 2n or n + 2." Some learners said that the two expressions were equal. They only saw "n" as equal to two. This confirmed that both procedural and structural conceptions should be harnessed – in other words, that learners should be made aware that $n + n \neq n + 2$. In order to assist learners to understand this, substitution and a table of values were used, while graphs were drawn to represent relationships between the two expressions. This study has found that the majority of learners who performed well in these kinds of problems are those who make use of computers to facilitate their representations of mathematical ideas. The present findings support the study of Ku, Harter, Liu, Thompson and Cheng (2004), which revealed that low achieving learners who used computer do better in problem solving than low achieving learners who do not use the computer.

5.1.3 Findings regarding the use of computer assisted collaborative learning in mathematics problem solving

Regarding computer-assisted collaborative learning, the study revealed that the learners who worked in groups while using computers performed better than those who used traditional methods in learning mathematics. These findings support Good and McCaslim, (1992) who maintain that dividing learners into small cooperative groups for instruction facilitates achievement and affective gains. By comparing problem solving processes and results with other learners, the learner begins to realise appropriate and inappropriate strategies used in a particular problem. Lee, (1999) seems to share the same view as the findings of the present study when he says that computer mediated communication enables students to negotiate meanings and construct knowledge in a situational context that enhances meaningful collaboration through collaborative problem solving.

In the qualitative analysis it was found that the majority of the learners said that they worked very well in groups because they discussed and explained to one another. This interaction amongst learners encourages an active dialogue between learners who are able to question techniques and solve problems that they encounter by themselves. These findings support Harasim (1989), who says that through collaboration students are exposed to multiple perspectives that serve to form cognitive scaffolds as the students resource information from each other (Lee, 1999). The findings also indicate that when learners work in groups in a computer environment they only need an educator to intervene with explanations when all members experience difficulty. However, the educator does not only provide mathematical help, he also provides technical and computer operational help as is acknowledged by Heids, Sheets and Matras (1990), and Cornelius, (1982). With this in mind, the interaction of the learners among themselves and with the computer in small groups is likely to yield better results in problem solving than those attained by traditional methods.

5.2 THE IMPLICATIONS OF THE FINDINGS OF THE STUDY TO EDUCATION

The current education system seems to advocate constructivism in teaching and learning. This has been evident in the implementation of outcomes-based education (OBE) and the national curriculum statement (NCS), which emphasises learner-centered teaching and learning as opposed to educator-centered learning according to the traditional approach. As a result, problem solving and the programmes that require the use of technology should be a focus of teaching and learning, particularly in mathematics education. It is important to note that problem solving should not be seen as a procedure that focuses mainly on the completion of the given task. As noted by Gadanidis (1988), educators must view problem solving as one of the important dimensions that need to be taken into consideration in the learning of mathematics. As mentioned before, these dimensions include the teaching of facts and skills; teaching for understanding; problem solving and the medium or tool used to facilitate teaching. According to this study, the essential tool to facilitate the understanding of the mathematics concepts in problem solving is a computer.

The findings of the present study confirm that a multiple, linked representation of a particular mathematical concept needs to be harnessed instead of treating each representation in isolation from the others. For instance, words, algebraic expressions, tables, flow diagrams, equations and graphs should be used to re-enforce one another in expressing the same idea. This study also draws attention to the present education system – in that while it intends adopting constructivism in teaching and learning, it needs to facilitate this by using technology (the computer) in subjects such as mathematics at elementary level. It is hoped that learners will be grounded with basic concepts when they advance to higher levels as without such grounding their progress is often hindered at those levels.

The computer is not only used to motivate learners to do algebra, but also to enable and encourage collaborative participation among them. This is the essence of OBE and NCS in the present education system, which requires learners to be active partners in their learning. The finding of the study indicate that cooperative learning is enhanced if learners are divided into small groups in a computer environment, as learners negotiate meanings and discover basic concepts and algebraic rules by themselves. According to the findings of the study the educator does not only provide mathematical assistance, but also technical and computer operational assistance to the learners. As a result, it is only the well-trained educators – those who have captured the potential of the technology themselves – who will be able to inculcate a love of computers among the learners (Sibaya & Sibaya, 2004). Mathematics educators will have to liaise with computer educators in order to ensure that they facilitate mathematics learning effectively.

5.3 GENERALISATION

The primary aim of this study has been to test the effects of using computer-assisted instruction in algebra problem solving as opposed to traditional approaches. It is therefore important to know whether the findings could be applicable to other learners elsewhere. As mentioned before, the study sample included learners from different environments, such as townships, informal settlements nearby townships and rural areas. This proves that the findings can, to a limited extent, be generalised to other grade eight learners in South Africa.

5.4 LIMITATIONS OF THE STUDY

During fieldwork, the researcher encountered certain difficulties, as listed below:

a) The instruments used in this study consisted of a test and a questionnaire that were not standardised; as a result the validity and the reliability of these instruments have not been established.

b) The nature of the study made it necessary for the researcher to do all the fieldwork on his own, as he wanted to be as close as possible to the learners so as to ensure that the administration of the tests was strictly controlled. In addition to this the computer programmes used in the study required a person with a background of both computer and mathematics.

c) The fieldwork interfered with the school timetable in some instances; as a result of clashes, the researcher could not follow the school timetable exactly and this caused problems regarding attendance.

d) Lack of computer background in the learners may have contributed negatively to the results because some of the learners struggled with computer usage, and this minimized time to solve the actual mathematics problems.

e) Learners were taught algebra by using computers; to some learners this could imply that they should also use the computer to write tests, while the study, on the other hand, sought to ascertain whether they could write what they had learnt through the computer even in the absence of a computer.

f) The time available for fieldwork seemed to be too short, as it did not give learners enough time to familiarize themselves with computer usage. As a result, learners had to double their efforts in trying to understand mathematics concepts and problem solving procedures while learning to master the computer.

g) The questionnaire was translated from English to IsiZulu in order to facilitate learners' understanding. This was intended to ensure that learners responded to the questions freely and efficiently in their mother tongue and in order to obtain their true perceptions of computer usage. However, it seems that this might have also have contributed to ambiguity with regard to some questions and to a loss of the intended meaning in the translation. In order to ensure that the two versions were equivalent, the researcher's assistant, the co-supervisor and the supervisor edited the translated version.

5.5 RECOMMENDATIONS

The present study has found that learners who are taught mathematics by using problem solving strategies with a computer as a tool to facilitate learning are likely to achieve better result in examinations, tests and assignments.

There are other factors that the researcher feels could have further strengthened the validity and reliability of the findings had they been taken into consideration. As a result, they need to be explored in future studies. To mention a few of them:

a) Validity and Reliability

The instruments used were not standardised and as a result no information was provided regarding validity and reliability. It is therefore important for future studies to use validated instruments.

b) The duration of the study

Having done fieldwork for a period of three months, the researcher feels that for future studies this period needs to be extended in order to give enough time to the learners to explore the effects of using a computer in mathematics learning. The reason is that learners are not at the same cognitive level. Some learners take a long time before they grasp mathematics concepts and rules, let alone having to double their efforts by trying to cope with the cognitive demands of mathematics on the one hand, while trying to master computer usage on the other. This difficulty could have compromised the degree of variation in the achievements of the experimental and control groups. Therefore it will be necessary for future studies of this kind to extend the duration of the fieldwork.

c) Knowledge of operating a computer

Some learners encountered the computer for the first time. As a result it was not surprising to note during the fieldwork that they were quite capable of performing much better had they only been more familiar with the computer. They often spent too much time trying to do what the computer told them to do. It is for this reason that the researcher believes that, in future, this kind of study should be conducted learners who have a background in computer usage.

d) Language proficiency

Language is one of the contributory factors in the high failure rate that is encountered in mathematics. The questionnaire was translated from English to IsiZulu so as to ensure that learners responded appropriately to questions posed in their mother tongue. However, during the translation of the questions from English to IsiZulu, certain ambiguities were noted that could have compromised the learners' understanding of the questions, which may have resulted in some of the vague responses. In future studies the instrument(s) used for a qualitative data should be designed in the learners' language, especially at elementary level.

e) Accommodation of other sections of mathematics in the study

The study focused mainly on the algebra aspect of mathematics. As a result we can only assume that the findings will be the same for other aspects, such as geometry and trigonometry. It is therefore necessary for future studies to make provision for sufficient time so that they can be conducted in grades where different aspects of mathematics are taught, so as to accommodate other aspects of mathematics in the findings.

5.6 ETHICAL CONSIDERATION

One of the important ethical aspects of the research projects was to deal with the participants' responses in a respectful manner. The researcher had to take into consideration the participants' rights as well as their protection during the whole research process. The ethical issues in question were as follows:

5.5.1 Informed Consent

Informed consent means the right of the research subjects to choose whether he/she wishes to participate (or not to participate) in the research project. For this reason, the researcher had to write letters to the district office, principals of the schools and to the learners' parents in order to get permission to conduct research. For this study the researcher also requested mathematics educators to assist learners during the teaching sessions, especially with regard to those who struggled with computer usage, so as to ensure that they were fully supported.

5.5.2 Information

The participants (learners) were given information regarding the purpose of the study as well as their roles in the study. The information was given verbally to the participants. However, the information given to the parents was in writing and in their home language so that they gain full understanding of the purpose of the study as well as to the way in which their children would benefit from this exercise. In the letters, all the details of the researcher, including the contact details were given. At the end of the letter, a space was provided for parents to sign in order to give consent for the learners to participate in the study.

5.5.3 Privacy, anonymity and confidentiality

Regarding privacy, anonymity and confidentiality, the researcher informed the principals of the schools that the information collected from their schools would be strictly confidential. Even if the information were to be published anonymity was ensured for both individual and school. The participants were also informed that the information they would provide in the questionnaire would not be linked to them or to their educators in order to ensure that privacy and confidentiality is maintained.

5.6 CONCLUSION

This chapter discussed the findings of the present study, which revealed that problem solving in mathematics is more meaningful when it is integrated with other components (dimensions) of teaching and learning mathematics. This is a multidimensional view of mathematics learning. The study furthermore showed that problem solving is nourished by using multiple representations and collaboration in a computer environment. These findings seem to be part of what is intended by the present education system, namely that of transforming traditional teacher-centred teaching into learner-centred teaching. The implications of the study to education have been discussed and an outline was given of the limitations and recommendations of the study. In conclusion, the researcher strongly believes that these findings cannot be regarded as an end in themselves. It is hoped that in future, several studies will be conducted in this field because very little has been done with regard to research in the teaching and learning of mathematics with the assistance of the computer in a South African context.

REFERENCES

Ausubel, D.P. (1968). *Educational psychology: A cognitive view.* New York: Holt, Rinehart and Winston.

Bell, F.H. (1978). Can computers really improve school mathematics: *The mathematics teacher:* 81, 428-433.

Booker, G. (1998). *Thinking mathematically: Problem solving as a solution for uncertain times.* Fourth National Congress of AMESA: Proceedings 1.

Booth, L. (1990). *The Australian mathematics teacher,* 46(3): 12-14.

Cangelosi, J.S. (2003). Teaching mathematics in secondary and middle school: *An interactive approach:* Merrill Prentice Hall.

Cornelius, M.L. (1982). *Teaching mathematics:* New York: Nichols Publishing Company: 36-66.

Creswell, J.W. (1994). *Research design: Qualitative and quantitative approach.* California: Sage.

Demana, F & Waits, B.K. (1990). Enhancing mathematics teaching and learning through technology: In T.J.Cooney & C.R Hirsch (eds). *Learning mathematics in the 1990s.* Virginia, Reston: NCTM.

Department of Education (2001). *National Strategy for Mathematics, Science and Technology Education in General and Further Education and Training.* Pretoria: Government Printer.

Douglas, H., Clements, D. & Sarama, J. (1996). Computer support: Algebraic thinking: *Teaching children mathematics:* 3, 320-325.

Ernest, P. (1991). Social constructivism as a philosophy of mathematics: *The philosophy of mathematics education.* London: Routledge Farmer.

Fey, J.T. (1989). School algebra for the Year 2000: In S. Wegner & Kieran C. (eds). *Research issues in the learning and teaching of algebra.* Virginia, Reston: NCTM.

Fraenkel, J.R. & Wallen, N.E. (1991). *How to design and evaluate research in education.* New York: McGraw-Hill.

Frankfort, C. & Nachmias, D. (1992). *Research methods in the social sciences.* London: Edward Arnold.

Gadanidis, G. (1988). Problem solving: The third dimension in mathematics teaching: *The mathematics teacher:* 81, 16-21.

Good, T.L.; Mulnyana, C & McCaslin, M (1992). Grouping for instruction in mathematics: A call for programmatic research on small-group processes. In D.A. Grouws (eds). *Handbook of research on mathematics teaching and learning.* New York: MacMillan.

Gray, D.E. (2004). *Doing research in the real world.* London: Sage.

Grouws, D.A. (1992). *Handbook of research on mathematics teaching and learning.* New York: MacMillan.

Harasim, L. (1989). Online- education: A new domain, http://www-icdl.open.ac.uk/mindweave/chap4.html.

Harskap, E.G. & Suhre, J.M (2004). Improving mathematical problem solving: A computerised approach. *Computer in human behavior.* 22(2006) 801-815, Elsevier: University of Groningen. Netherlands.

Hart, M. (1982). Using computer to understand, four years on: *Mathematics teaching,* Nos. 98-101.

Heid, M.K.; Sheets, C. & Matras, M.N (1990). Computer enhanced algebra: New roles and challenges for teachers and students: In T.J. Cooney & C.R. Hirsch (eds). *Teaching and learning mathematics in the 1990s.* Virginia, Reston: NCTM.

Hiebert, J; Carpenter, T.P; Fennema, E.; Fuson, K.; Human, P.; Murray, H.; Olivier, A. & Wearne, D. (1996). Problem solving as a basis for reform in curriculum and instruction: The case of mathematics. *Educational researcher,* 25(4) 12-20.

Hobden, P. (1994). *The role of problems in the teaching of physical science.* In M. Glencross (eds). Proceedings of the second annual meeting of Southern African association for research in mathematics and science education, University of Transkei: Umtata.

Janvier, C. (1978). *The graphical representation of situations.* Nottingham, U.K.: University of Nottingham.

Kamii, C. (1990). Constructivism and beginning arithmetic (K-2): *Teaching and learning mathematics in the 1990s.* Virginia, Reston: NCTM.

Kaput, J. (1989). Linking representations in the symbol systems of algebra. In S.Wagner & C. Kieran (eds.). *Research issues in the learning and teaching of algebra.* Virginia, Reston: NCTM.

Kaput, J. (1992). Technology and mathematics education. In D.A. Grouws(ed). *Handbook of research on mathematics teaching and learning.* New York: Macmillan.

Khan, F. (2000). *Contextual factors associated with mathematics anxiety: Perception of teachers and students at a secondary school in Kwa Zulu Natal.* Unpublished MEd. dissertation, Durban: University of Natal.

Kieran, C. (1992). The learning and teaching of school algebra. In D.A. Grouws (ed). *Handbook of research on mathematics teaching and learning.* New York: MacMillan.

Ku, H.; Harter, C.A.; Liu, P.; Thompson, L. & Cheng, Y. (2004). The effects of individually personalized computer-based instructional program on solving mathematics problems. *Computers in human behavior,* 23(2007) 1195-1210, Elsevier. University of Colorado: USA.

Kuchemann, D. (1978). Children's understanding of numerical variables. *Mathematics in school.* 7:23-25.

Kuchemann, D. (1982). Algebra. In K.M. Hart (ed.). *Children's understanding of mathematics*. London: John Murray.

Lee, C.S. (1999). Problem solving in constructivist environment: *Educational technology and society.* 2:137-142.

McConnell, J.W. (1988). Technology and algebra: In A.F. Coxford & A.P. Shulte (eds.) *The ideas of algebra K-2.* Virginia, Reston: NCTM.

Mji, A & Makgato, M (2006). Factors associated with high school learners' poor performance: a sport light on mathematics and physical science. *South African Journal of Education,* 26(2)253-266

Moll, I. (2002). Clarifying constructivism in a context of curriculum change: *Journal of Education. 27*: 4-28.

Myeza, Q.A. (1998). *Causes of poor performance in Grade 12 mathematics: Background knowledge of fundamental mathematical procedures.* Unpublished Med. Dissertation, KwaDlangezwa: University of Zululand.

Nickerson, R.S. (1985). Understanding understanding: *American journal of education,* 93(2):210-217.

Noss, R. (1988). The computer as a cultural influence in mathematical learning: *Educational studies in mathematics,* 19(2) 257-265.

Nyawuza, P.R. (2004). *An investigation into development planning by primary school's management.* Unpublished Med. Dissertation, Kwa Dlangezwa: University of Zululand.

Nyuswa, Y.N. (2003). Outcome-Based education and under-resourced schools. *Evaluative study.* Durban.

Orton, A. (1987). Can pupils discover mathematics for themselves: *Learning mathematics*. London: Cassel Education.

Pillay, S. (2005). *The relationship between educator's perceptions on change management and educators' attitudes towards change: A case study of IQMS implementation at primary school.* Unpublished Med. Dissertation, Durban: University of KwaZulu Natal.

Pimm, D. (1995). *Symbols and meanings in school mathematics*. New York: Routledge.

Polya, G. (1981). *Mathematical discovery.* New York: Stanford University.

Polya, G. (1945). *How to solve it.* Princeton University Press.

Ruthven, K & Hennessy, S. (2002). A practitioner model of the use of computer- based tools and resources to support mathematics teaching and learning. *Educational studies in mathematics, 49(1) 47-73*. Kluwer Academic Publishers.

Sajka, M. (2003). A secondary school student's understanding of concept of function. A case study. *Educational studies in mathematics, 53: 229-254.*

Schoenfeld, H. (1985). *Mathematical problem solving.* University of California: Academic Press.

Secada, W.G. (1992). Race, ethnicity, social class, language and achievement in mathematics. In D.A. Grouws (ed.) *Handbook of research on mathematics teaching and learning.* New York: McMillan.

Senk, S.L. (1989). Toward algebra in the year 2000. In S. Wagner & C. Kieran (eds.). *Research issues in the learning and teaching of algebra.* Virginia, Reston: NCTM.

Sfard, A. (1994). The gains and pitfalls of reification: The case of algebra. *Educational studies in mathematics,* 26: 191-227.

Sibaya, P.T. & Sibaya, D.C. (2004). *To determine the extent of effective computer literacy among educators and public service (PS) personnel.* Unpublished research project commissioned by KZN DoE. KwaDlangezwa: University of Zululand.

Sibaya, P.T.; Sibaya, D.C. & Mugisha, R.X. (1996). Black secondary school pupils' problems with mathematical concepts. *South African Journal of Education, 16(1): 32-37.*

Sierpiska, A. (1992). On understanding the notion of a function. In G. Harel; and E. Dubinsky (eds), *The concept of function: Aspects of epistemology and pedagogy,* 25: 25-58.

Skemp, R. (1976). Relational understanding and instrumental understanding. *Mathematics teaching,* 77:20-26.

Steffe, L. & Wiegel, H. (1994). Cognitive play and mathematical learning in computer microworlds. *Educational studies in mathematics, 26:* 111-134. Kluwer Academic Publishers.

Stott, A.E. (2002). *A case study of a high achiever's learning of physical science*: Unpublished Med. Dissertation, Durban: University of Natal.

Thalheimer, W & Cook, S (2002) *How to calculate effect sizes from published research articles: A simplified methodology*. Retrieved February 23, 2008 from http://work-learning .com/effect_sizes.htm.

Tuckman, B.M. (1988). *Conducting educational research.* Florida State University: Harcourt Brall Jovanovich, Inc.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes.* In M. Cole, V. John Steiner, S. Scribner & E. Souberman (eds and trans). Cambridge, MA: Harvard University Press.

Wegner, S. & Kieran, C. (1989). The early learning of algebra: A structural perspective. In S. Wegner and C. Kieran (eds.) *Research issues in the learning and teaching of algebra.* Virginia, Reston: NCTM.

Yerushalmy, M. (2000). Problem solving strategies and mathematical resources: Longitudinal view on problem solving in a function based approach to algebra. *Educational studies in mathematics.* 43(2):125-147. Kluwer Academic Publishers.

Zevenbergen, R. (2001). Language, social class and underachievement in school mathematics. In P. Gates *Issues in mathematics teaching.* Routledge: London.

ANNEXURE A

Research Unit for Mathematics Education

University of Stellenbosch

Project: Teaching and Learning Algebra

You are participating in research on improving the teaching and learning of algebra. So it is very important that you *explain your reasoning in writing* and try your best in *each* question.

Your name:--

Test 1

A. Themba now has R50 in the bank. After one month and then every month thereafter he saves R4. How much money does he have in the bank after:

1. 10 months?---

   ----

2. 25 months?---

   ----

3. x months (x is the number of months he has saved money)?

   ----

4. After how many months will he have a total of R250 in the bank? ---

----

B. The science class measured the growth of a plant seedling over a two weeks period. The following information was recorded:

Days	0	2	4	6	8	10
Heights (mm)	0	3	6	9	12	15

5. What was the height of the seedling after 11 days?

----

6. If the plant continued to grow at the same rate, after how many days would it be 60 mm high? ---

----

Test 2

C. Sipho thinks of a secret number. He then multiplies the number by 7, then subtracts 12, giving an answer of 100.

7. If his secret number is s, write an *equation* to show the process: -----

----

8. Draw a flow diagram to show the process:

----

9. What is Sipho's secret number?---

Test 3

D.

10. You are told that $x + 7 = 12$. What can you say when $x = 2$? ---------

----

11. $x = 5$?--

E.

12. Which is larger: $2n$ or $n + 2$?--------------------------------

13. Explain your reasoning: --

F. The cost of a taxi ride is found from the formula $C = 80 + 25x$ where x is the *number of minutes* the ride lasts and C is the *cost in cents*.

a. What is the cost for a ride of 10 minutes? ------------------------------

----

b. If a taxi ride costs R8,30 how many minutes did you ride?

Test 4

G.

16. What is the formula for the perimeter of a rectangle?-------------

17. A rectangle has a perimeter of 48 cm and a length of 14 cm. What is its breath?--

----

18. In a rectangle, the length is 3 cm longer than the breath, and the perimeter is 50 cm. What is the length of rectangle?-----------------

----

Test 5

H. Given the equation $5x + 12 = 3x + 24$.

19. Which one of these is the solution of the equation? Mark with a tick or a cross $x = 3$ $x = 5$ $x = 6$ $x = 8$

20. Explain *why* it is the solution: ----------------------------------

----

21. Which of these equations also have the same solution? Mark any with a tick or a cross

$4x + 12 = 2x + 24$ $2x + 12 = 24$

$3x + 12 = 5x + 24$ $5x = 3x + 12$

I. In each case below, find the value of x that makes the statement TRUE (*solve* the equation). *Show all your work!*

22. $5 - x = 2$ --

----

23. $6x = 64$ --

----

24. $x + x = 76$ --

----

25. $55 = x + 5 + x$ --

----

26. $2x + 6 = 2(x + 3)$ --

ANNEXURE B

QUESTIONNAIRE (Original)

Participant's Details:

Participant's Name:

Place/School:

Date:

A. 1. Can you tell me how you use/d the computer for doing mathematics

(i) At the beginning of being introduced to the technology?

(ii) Now?

(iii) How do/did you understand the instructions in the problem when you use/d the computer?

----

2. How do/did you feel when

(i) You use/d computer to do mathematics? Were/are you happy? Worried you do not know how to use the computer? Comfortable, you know how to use and work with the computer?---

----

(ii) What is your understanding of mathematics like now?

---

2. Describe your understanding of mathematics

(i) Now? Is it getting better? Getting poorer? Becoming superb? Not changing? Explain each choice.

(ii) In future, will it get worse? Will it improve? Will it not change?

---

3. Are/were you able to read and understand instructions in the mathematics problem

(i) At the beginning of using the computer? Was it better? Getting worse? Not changing?

(ii) Now? It is getting better? Is it getting worse? Has it changed? Describe the change. What else?

B. 5. What do/did you do to ensure that you use/d the correct approach in solving a problem?

(i) At the beginning of using technology? Do/did you summerise using words, table, a picture, a graph, ask/ed for help from the partner? --

----

(ii) Now? Describe what you do when you solve a problem.

----

6. Explain how the following help you when doing mathematics

(i) Flow diagrams : --

(ii) Tables

(iii) Graphs

(iv) Equations

(v) Formula

C. 7.(i) Explain how you worked together when solving algebra problems

----

(ii) Who explain/ed when all had/have difficulties?

(iii) Who always explain when you had/have a serious problem?

----

8. If you were/are working individually (alone) do you think you would do more algebra problems?

----

9. (i) Were/are you helping one another in doing algebra problems in computer?

(ii) Did you open time to discuss issues related to the mathematics problem at hand?

(iii) Do/did you give no opportunity to anyone to waste time, did you all concentrate on the task?

(iv) How often did the educator tell you to concentrate on your work?

ANNEXURE C

QUESTIONNAIRE (Translated version)

Participant details:

Place/Site/School:

Date:

A 1. Ungangitshela ukuthi ubusebenza kanjani ingakabibikho ikhomputha uma wenza isibalo?

(i) Ekuqaleni

(ii) Manje---

(iii) Uyizwe kanjani imiyalelo kulomsebenzi ngenkathi usebenzisa ikhomputha?

----

2. Uzizwa unjani uma usebenzisa ikhomputha ukwenza imathematics? Kuyakuthokozisa?, Kuyakukhathaza? Chaza. ------------------------

----

----

3. (i) Chaza indlela oyiqonda ngayo imathematics uma usebenzisa ikhomputha: Manje kuya ngokubangcono?, Kukubuyisela emuva?, Noma kuyazifanela nje?

(ii) Ngokuzayo ngabe kuzobheda kakhulu?, Kuzobangcono?, Akuzukushintsha? ---

----

4. Uyakwazi, uyakwazi ukufunda uqonde (understand) imiyalelo (instructions) uma wenza imathematics:

(i) Ngenkathi usaqala ukusebenzisa ikhomputha. Chaza

(ii) Manje? Kuyangokubangcono?, Kuyabheda?, Sekunoshintsho? Chaza ---

----

B. 1. Wenzani ukuqinisekisa ukuthi usebenza ngendlela eyiyo yokubhala isibalo?

(i) ---

(ii) Ngenkathi uqala ukusebenzisa ubuchwepheshe ngabe wawufinqa ngokusebenzisa amazwi, ithebula, izithombe, igrafu. Wabuza wacela usizo komunye?---

----

(iii) Manje chaza indlela oyisebenzisayo uma wenza isibalo.

----

2. Chaza ukuthi okulandelayo kuwusizo kanjani kuwe

(i) Flow diagram?

(ii) Table?

(iii) Graph?

(iv) Equation?

(v) Formula?

C. 3. (i) Chaza ukuthi nisebenze kanjani nindawonye?

(ii) Ngubani ochazela omunye lokho okulukhuni?

(iii) Ngubani osizayo sonke isikhathi?

---

4. Uma uzenzela ngawedwana wawungenza izibalo eziningi?

---

5. Wena nabangani bakho:

(i) Benisizana uma nenza izibalo?

(ii) Benichitha isikhathi nikhuluma ngezindaba ezihlangene nezibalo?

(iii) Akekho obevunyelwa ukumosha isikhathi nonke benenza izibalo?

(iv) Kukangaki uthisha enikhuza ethi bhekani umsebenzi wenu?

ANNEXURE D

E-MAIL: APPLICATION FOR RESEARCH INSTRUMENTS AND RESPONSE

> -----Original Message-----
> From: Khetha Biyela [mailto:khetha@thekwinicollege.co.za]
> Sent: Thursday, November 29, 2007 2:16 PM
> To: Olivier, Alwyn <aio@sun.ac.za>
>Subject: Research unit for mathematics education

Dear Sir

Kindly allow me to use your instrument in my research study. The topic of the instrument is: Research unit for mathematics education. If you do allow me please forward me with details of the instrument regarding its validity and reliability.

Thanks
KB Biyela

Dear Khetha

You are very welcome to use the instrument.

However, it is merely a test/questionnaire, not a standardised instrument, so there is no information available regarding its validity and reliability.

Kind regards
Alwyn Olivier

Director: Research Unit for Mathematics Education
Faculty of Education
University of Stellenbosch
Private Bag X17602
Matieland
Tel: (+27) 021 808 2299 or 083 292 4077
Fax: (+27) 021 887 2616
E-mail: aio@sun.ac.za
Homepage: http://www.sun.ac.za/mathed/

APPENDIX A

Letter requesting permission to conduct research at Mthunzini district.

P. O. Box 24018
KwaDlangezwa
3886
05/02/2007

The Circuit Manager
Mthunzini District
Department of Education

Sir

Re: Permission to conduct research in schools

I am a student at the University of Zululand. I am presently in the process of completing my Masters Degree in educational studies. Part of the requirements towards the completion of the Masters programme is the presentation of a research dissertation in the field of education.

For my research I have chosen the topic: **THE USE OF COMPUTERS AND PROBLEM SOLVING IN ALGEBRA.** I therefore require your permission to conduct the research in some schools in your circuit.
I also understand that as a researcher I am bound by the ethics of research to respect confidentiality of the participants and the schools where research is conducted.

I will appreciate your cooperation if my request reaches your full consideration.

Yours faithful

K.B. Biyela

PROVINCE OF KWAZULU-NATAL	ISIFUNDAZWE SAKWAZULU-NATAL	PROVINSIE KWAZULU-NATAL

MTHUNZINI DISTRICT OFFICE

Ikheli Lendawo Physical Address Fisiese Adres	:	*H 2680 Mthole Road* *Esikhawini* *3887*	Isikhwama Seposi Private Bag Privaatsak	:	*X8512* *Esikhawini* *3887*
Telefax Number Ucingo Telephone	:	*035 – 796 0134* *035 – 796 4012/155/000* *035 – 796 4012/155/000*	Imibuzo Enquiries Navrae	:	*District Manager*
Usuku Date Datum	:	11/02/07	Inkomba Reference Verwysing	:	2/12

THE PRINCIPAL (s)
Mthunzini Circuit.
....
....

11 FEB 2007

AUTHORITY TO VISIT SCHOOLS WITHIN THE MTHUNZINI DISTRICT

1. Bearer ~~DR/PROF/MR/MRS/MISS~~ Bhela KB. representing UNIZUL has been granted permission to visit your school(s) on matter affecting schools, learners, educators and SGB's.

2. The agreement is on the proviso that there will be no disruption of classes or disturbances to the school as a whole. It is further emphasized that should the school require an appointment prior to attention, the applicant will oblige.

3. Hoping his/her visit will be of assistance to both parties.

....

DISTRICT MANAGER: MTHUNZINI

TR CEBEKHULU/school visits

11 FEB 2007

APPENDIX B

Letter to school principal requesting permission to conduct research

P.O. Box 24018
KwaDlangezwa
3886

The Principal

Sir/madam

Re: Request for permission to conduct research

I am a student at the University of Zululand. I am currently studying for a master's degree in mathematics education. My dissertation is on "**The use of computers and problem solving in algebra".** I therefore request permission to conduct research in your school.

I also understand the ethics of research to respect confidentiality. Therefore all information will be treated with confidentiality under no circumstances will the name of your school be mentioned in the dissertation.

I will appreciate your cooperation if my request reaches your full consideration.

Yours faithful

K.B. Biyela

I, the Principal hereby grant permission to Mr K.B. Biyela to conduct the research in this institution.

Signed:------------------ at ------------ on------------February 2007

APPENDIX C

Letter to parents requesting permission for learners to participate in a research

P.O. Box 24018 Kwa-Dlangezwa 3886 05 February 2007	P.O. Box 24018 Kwa-Dlangezwa 3886 05 February 2007
Dear Mr/s ------------------	Mzali----------------------
Permission for a learner to participate in a research	**Imvume yokuba umfundi abe Yinxenye yocwaningo**
I am currently studying towards Masters Degree in Education at the University of Zululand. One of the requirements of this Degree is to write a dissertation on "**The use of computers and problem solving in algebra in algebra".**	Njengamanje ngenza iziqu ze Masters e-Nyuvesi yakwa Zulu. Okunye kumina ekuqedeleni leziziqu, ukuba ngibhale ngokusebenza kwecomputer ekwenzeni izibalo.
To complete my dissertation I need to get information from learners by asking them to fill in the questionnaire and to write an algebra test. I therefore ask your permission to allow your learner to participate	Ukuze ngiqede ngidinga ukuthola izimpendulo zemibuzo engizombuza yona kanye nokubhala isivivinyo ulwazi oluthile kumntwana wakho kulokho okade ekufunda. Ngakhoke ngicela umvumele ukuthi abe inxenye yalolucwaningo.
All information provided will be confidential Be confidential.	Lonke ulwazi oluyotholakala kumntanakho luyogcinwa luyimfihlo
I will appreciate your assistance in this regards.	Ngiyolubonga usizo lwakho kulesisicelo
Yours faithfully -------------------- K.B. Biyela	Owakho ozithobayo ------------------------ K.B. Biyela
I hereby grant/ do not grant permission for my child to participate	Ngiyavuma/ Angivumi ukuba umntanami abe yinxenye yocwaningo.
Yours faithfully --------------------(parent)	Owakho ozithobayo -------------------- (umzali)