

INFORMATION TECHNOLOGY AS AN INSTRUCTIONAL TOOL IN THE TEACHING OF
MATHEMATICS IN SECONDARY SCHOOLS: PERCEPTIONS OF EDUCATORS AND
LEARNERS IN THE NORTH WEST PROVINCE.

BY



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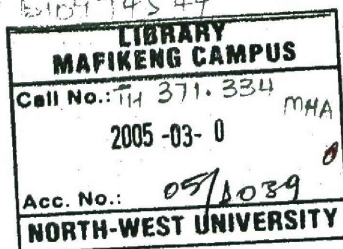
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DECLARATION



I declare that the dissertation for the degree of Master of Education at the North West University hereby submitted has not previously been submitted by me for a degree at this or any other university, that it is my own work in design and execution and that all materials taken from other sources contained herein have been duly acknowledged.

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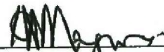
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- Above all, God almighty for my life and good health throughout the year I was busy with this project.

CERTIFICATE OF ACCEPTANCE FOR EXAMINATION

This dissertation: Information technology as an instructional tool in the teaching of mathematics in secondary schools: Perceptions of educators and learners in the North West Province of the Republic of South Africa; written by Duncan Mhakure, student Number 10609814 of the Department of Professional Studies and Internship in the Faculty of Education is hereby recommended for acceptance for examination.

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ABSTRACT

The title of this research study is: Information technology as an instructional tool in the teaching of mathematics in secondary schools: Perceptions of educators and learners in the North West Province of the Republic of South Africa. This research study was intended to study the role played by information technology as an instructional tool in high schools and the challenges associated with the integration of information technology in the teaching and learning of mathematics in high schools.

The research study sought to investigate the following research questions:

- Is information technology an effective instructional tool to teach secondary school mathematics?
- What are the perceptions of educators and learners regarding the use of computers in mathematics lessons?
- What are the challenges faced by educators and learners when using Information technology in the teaching and learning of mathematics?

This research study drew its population from all high schools in the Mafikeng, Zeerust and Lichtenburg Districts of the North West Province, which used computers in teaching. A sample of eight high schools was used; two in the Zeerust District, two in the Lichtenburg District and four in the Mafikeng District. This research sample was made up of mathematics and computer studies educators and learners from the chosen secondary schools. Two questionnaires were used for the purposes of data collection. One of the questionnaires was intended to study the perceptions of learners on the use of information technology in teaching and learning mathematics and the other was intended to study the perceptions of educators on the use of information technology in mathematics education.

Both quantitative and qualitative techniques were used to analyse the research. The main findings of the research study were that:

- The majority of educators (76%) regarded information technology as an effective instructional tool in the teaching and learning of secondary school mathematics.

- Educators were generally not well trained to use information technology as an instructional tool and that there was a shortage of hardware and software due to financial constraints in high schools.

I have recommended that:

- The Department of Education, in conjunction with the Faculty of Education of the North West University should organise in-service programmes on the use of information technology as an instructional tool in the teaching and learning of mathematics.
- More research studies are required in the development of relevant and appropriate software for use in the teaching and learning of mathematics.

In conclusion, the researcher hopes that the use of Information technology will go a long way in enhancing the learning and teaching of mathematics in high schools throughout the North West Province of the Republic of South Africa.

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1 CHAPTER ONE: INTRODUCTION AND ORIENTATION

1.1 INTRODUCTION

As a result of information technology, mathematics education is probably at its biggest watershed of all time. Information technology has profound implications and offers great opportunities for the mathematics curriculum. Significant progress has been made in translating these into classroom realities over the last decade, despite a number of very real impediments. However, the effects seen in the typical developing world classroom still remain disappointingly modest. The rapidly changing nature of technology both in and outside the school environment exacerbates the difficulties. Continuously changing technology implies continuously changing the curriculum to suit the ever demanding needs of the society. Sadly, opportunities for such necessary evolution are not built into the national curriculum. Furthermore, changes in examination syllabus arguably offer the most effective agent for change in secondary schools, but traditional written assessment is particularly unsuited to testing the most valuable work that can be done with computers in the classroom. I am cognisant of the fact that the South African mathematics curriculum is currently examination oriented, thereby rendering the use of computers limited as far as examinations are concerned. In a way, this research project was concerned mainly with the contributions of information technology in enhancing the learning and teaching of high school mathematics. Equally important to this research project was the fact that there would be obstacles to be dealt with as we endeavour to integrate information technology into the mathematics curriculum.

This research project was intended to study information technology as an instructional tool and the challenges which come with the use of information technology in the teaching and learning of mathematics. Traditional educational goals reflected society's emphasis on "the need for basic skills", that is, writing, reading and arithmetic. Learners were considered educated if they could demonstrate the abilities to read at a certain comprehension level; apply grammar, usage and punctuation rules in written compositions, multiplication and division, and state certain series of facts, for example historical events. In the Post-modernism era, there is a change of emphasis on the educational goals. There is a complete change in the way in which we view the world as reflected in both science and the humanities. A post-modernism curriculum will accept the learner's ability to organise,

construct and structure, and will emphasise this ability as a focal point in the curriculum (Doll, 1989, p250). Information technology can be used as an effective instructional tool in the teaching and learning of mathematics in the post-modernism era.

In this research project, the educational theories of Jean Piaget, Jerome Bruner and Levy Vygotsky have been discussed in the literature review. The relevance of these educational theories to this research project is that these theories are compatible with the use of information technology as an instructional tool.

South Africa has adopted the Outcomes Based Education system. The Outcomes Based Education system is intended to produce learners who are literate, numerate and multi-skilled, but who are also confident and independent, compassionate, environmentally respectful and able to participate in society as critical and active citizens. At Senior Phase Mathematics, the ability to use appropriate technology to demonstrate mathematical concepts is seen as paramount. The latter can promote the use of information technology as an instructional tool. The use of information technology in the teaching and learning of mathematics remains a challenge in the North West Province

Papert (1980) was an early critic of traditional approaches to teaching and learning that emphasise isolated skills. Papert advocated for a less structured environment that would allow learners to use computers to learn to think and solve problems.

There is literature on researches carried out on the use of information technology in the teaching and learning of mathematics in developed countries. South Africa is also embracing the use of information technology in the teaching and learning of mathematics. The motivation behind this research is to find out the educator and learner views on the teaching and learning of mathematics.

1.2 STATEMENT OF THE PROBLEM

The role of information technology as an instructional tool in the teaching and learning of mathematics has increased in the past decade. There has been contrasting views on whether the use of technology as an instructional tool in the teaching and learning of mathematics has yielded the desired results, that is, improve learning environments in third world countries

like South Africa. The latter has prompted me to embark on this research study.

This research study assessed the views of educators and learners regarding the effectiveness of information technology as an instructional tool in enhancing the teaching and learning of secondary school mathematics. In addition, the study explored the challenges faced by both educators and learners as they endeavoured to use information technology in the teaching and learning of secondary school mathematics in their respective high schools.

1.3 RESEARCH QUESTIONS

I wanted to investigate the following questions:

1. Is information technology an effective instructional tool to teach secondary school mathematics?
2. What are the perceptions of learners and educators regarding the use of information technology in the teaching and learning of mathematics?
3. What are the challenges faced by educators and learners when using information technology in the teaching and learning of mathematics?

1.4 PURPOSE OF THE STUDY

The vision for technology supported reform-oriented classrooms is one in which learner groups work on long term and multidisciplinary projects involving challenging content that is interesting and important to them with the support of information technology tools for collecting, analysing, displaying and communicating information. Making this vision a reality poses many challenges. This research study was intended to:

- Investigate the effectiveness of information technology as an instructional tool to teach secondary school mathematics.
- Shed light on the perceptions of learners and educators regarding the use of information technology in the teaching and learning of mathematics in high schools.
- Investigate on the challenges faced by educators and learners when using information technology in the teaching and learning of mathematics in high schools.

Apart from discovering the challenges faced when educators use information technology as a critical part of an inquiry-oriented teaching process, the research study intended to explore the classroom opportunities provided by the use of information technology in the teaching

and learning of mathematics. The study of classroom opportunities was to shed light on whether information technology enhanced the teaching and learning of mathematics or not.

1.5 SIGNIFICANCE OF THE STUDY

Piaget (1977) asserts that learning occurs when learners engage in an active construction of meaning, rather than merely becoming passive recipients in the teaching and learning process. The use of information technology can assist in the implementation of this constructivist theory of learning. This research study intended to show the importance of using information technology as a tool for meaningful learning in the Mafikeng, Zeerust and Lichtenburg Districts, in other words, information technology as an instructional tool for the teaching and learning of mathematics. The study will hopefully provide insight into the challenges associated with the use of information technology in the teaching and learning of mathematics. The conclusions drawn from this research study will allow policy-makers to design a curriculum, which integrates the use of information technology in the teaching of mathematics. The research study results present information technology as an alternative resource for learners as they study various subjects of their curriculum. Equally important is the fact that the findings of research will provide a platform for further research work on the use of information technology in the teaching and learning of mathematics in schools. The curriculum developers and the institutions involved in Teacher Education might find the research findings of this study an eye opener in their fields of operation.

1.6 LIMITATIONS OF THE STUDY

This research study intended to assess the effectiveness of information technology as an instructional tool in the teaching of secondary school mathematics in the Mafikeng, Zeerust and Lichtenburg Districts. A sample of eight schools was used in the research study. The sample of schools chosen in all three districts had computers, but were not necessarily using them on a daily basis. The latter was to vary from school to school. Learners of the randomly chosen secondary schools participated in the research study. Educators of the chosen secondary schools who taught mathematics and computer science also participated in the research study. Due to time constraints, the study could not include all high schools in the Mafikeng, Zeerust and Lichtenburg Districts.

1.7 DEFINITION OF TERMS

CD-ROM:	This is a compact disk-read only memory. It is an optical disk, capable of storing large amounts of data (650+ MB) (Jacobs, 2002).
Cognitive development:	According to Piaget, infants are born with schemes operating at birth that he called "reflexes". In other animals, these reflexes control behaviour throughout life. However, in human beings as the infant uses reflexes to adapt to the environment, the reflexes are quickly replaced with constructed schemes. As schemes become increasingly complex (i.e. responsible for more complex behaviours) they are termed structures. As one's structures become more complex, they are organised in a hierarchical manner (i.e. from general to specific). The latter process is called cognitive development and takes four main stages: sensor-motor; pre-operational, concrete operational and formal operational (Piaget, 1977).
Formative Assessment:	Refers to assessment that takes place during the process of learning and teaching. Its purposes may be to diagnose learner strengths and weaknesses, provide feedback to learners on their progress (or lack of), assist both the learner and educator or assessor to plan future learning, assist the learner and educator or assessor to make decisions regarding the readiness of the learner for summative assessment. This assessment is not intended to be used for assessing whether the learner has successfully achieved or not in terms of being awarded a credit or certificate (South African Qualification Authority, 1995).
Hardware:	Refers to, for example, the screen, the keyboard, all the

cables and components inside the computer. Hardware is therefore all the parts of a computer that you can touch (Jacobs, 2002).

Computer: A computer is an automatic, information-processing machine, which inputs, processes and outputs data under the control of a store program (Crawford, 1999, p 28).

Information technology: The use of computer based technology to store, process and transmit information. The current interest centres on computing, telecommunications and digital electronics (Rogers et al, 1999, p 6). In this study information technology specifically refers to the use of computers as an instructional tool to enhance the teaching and learning of mathematics in secondary schools.

Instructional Tools These are materials, representations and technologies that can be used as illustrations when teaching mathematical concepts

Software: Is the collective name for all types of computer programs. A computer program is simply a large collection of instructions, which tell the computer how to do a specific job. Examples of software include Windows, DOS, Word Perfect, Microsoft Word, Microsoft Excel, etc (Jacobs, 2002).

Summative assessment: Type of assessment concerned with final summing up. The judgements it makes are for the benefit of people other than the learner. Usually the concern is to differentiate between pupils, so that selection can be made. This type of assessment often comes at the end of a course, or a school career. It is entrenched in the public examination system. The real danger though, is that summative assessments, particularly external examinations, may determine rather

than reflect the nature and methodology of the curriculum (Bray and Johnson, 1996).

Zone of proximal development: This is the distance between the actual development level as determined through independent problem solving and the level of potential development as determined through problem solving under the guidance or in collaboration with more capable peers or expert adults. (Vygotsky, 1978, p.90)

2 CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 INTRODUCTION – WHY USE INFORMATION TECHNOLOGY IN SCHOOLS?

In exploring the reasons for introducing information technology into schools, we often find two major justifications. There are different agendas operating and several groups who have an interest in the process that is politicians, educators, the computer industry, parents and learners. There are many different variations of these arguments put forward from often opposing viewpoints.

The first reason often given for computers in schools is that children need to learn about computers because they need to know about computers later in life. This argument appears in various forms and philosophical orientations. At one extreme people believe that skills in using computers and software will open up employment prospects for learners. Somewhat removed from this view is the belief that learners need to have an understanding of the technology to become informed citizens able to deal with the complex world of the 21st century. In between there are other views. The argument against rapid change in technology and the employment of the equipment and software that today's school learners use when they enter the work force. The equipment will be radically different from that which they use now (Hunt, 1996).

The second viewpoint is probably more generally accepted amongst the educational community today. The second broad reason for information technology in education is that it helps learners in their present occupation as learners. This may propose that learners can learn more efficiently or become more motivated through computer-aided learning or intelligent tutoring systems, even to the extent that these may replace educators (Hunt, 1996). A more liberal view sees the value of information technology in providing an instructional tool which learners can use to explore the world. Information technology may also be seen largely as a communication device by which learners can access information (Hunt, 1996).

Because computer technology is expensive, strong justification is needed for its wholesale installation in our schools. We need reasons why educational tools of the past are no longer suitable for the present and the future. This justification is based upon perceived changes in society and its schooling needs. These changes, it can be argued, lead to the need for new

and more appropriate methods of teaching. Calls for the redesign of the education system are widespread throughout the world and come from all people of different walks of life.

Back home in the North West Province, educators and learners use a variety of instructional tools to enhance the teaching and learning of mathematics. These instructional tools include calculators, videotapes, and modelled units of shapes, games, laboratory experiments and computers. The media in the form of television (Liberty Learning Channels) has proved to be a good instructional tool. However, some schools have very limited resources in as far as instructional tools are concerned and tend to limit themselves to the more traditional chalk and talk strategies which rely extensively on the textbook. The latter provides a limited approach to the teaching and learning of mathematics. Hence learners, due to the limited teaching approaches used to teach mathematics, have found the subject very difficult and unmanageable. Some students even refer to the subject as most boring irrelevant subject in our school curriculum.

However, some schools have started implementing Information technology as an instructional tool. This is a very big challenge to the schools. Although the use of information technology in the teaching of mathematics has become part of the curriculum in some Western countries, in South Africa the concept is yet to be fully implemented. The challenge therefore, rests on our educators to implement their acquired educational theories in the teaching of mathematics using information technology. In this chapter, examples of benefits and challenges on the use of information technology in the teaching of mathematics from previous research have been explored.

2.2 THEORIES OF EDUCATION RELATED TO THE RESEARCH STUDY

The following section gives a brief description of some of the theories of education related to this research study.

2.2.1 THE THEORY OF CONSTRUCTIVISM

Constructivism is a philosophy of learning based on the concept that when individuals learn they do not passively acquire or absorb a new understanding. Instead, new information is actively assimilated into existing cognitive structures while simultaneously altering these

structures. Therefore, what individuals learn is always framed within the context of what they already know; each of us generates our own models and our own individual understanding of the world (Piaget, 1977).

According to SEDletter (1996) constructivism has the following four important implications for teaching.

First, teaching cannot be viewed as the transmission of knowledge from enlightened to unenlightened. Constructivist teachers do not take the role of the “sage on the stage”. Rather, teachers act as “guides on the side” who provide students with the opportunities to test the adequacy of their current understanding.

Second, if learning is based on prior knowledge, then teachers must note that knowledge is constructed and provide learning environments that exploit inconsistencies between learners’ current understanding and the new experiences before them. This challenges teachers; for they cannot assume that all children understand something in the same way. Further, children may need different experiences to advance to different levels of understanding.

Third, if students must apply their current understanding to new situations in order to build new knowledge, then teachers must engage learners in learning, bringing students’ current understanding to the forefront. Teachers can ensure that learning experiences incorporate problems that are important to students, not those that are primarily important to teachers and the educational system. Teachers can also encourage group interaction, where the interplay among participants helps individual students become explicit about their own understanding by comparing it to that of their peers.

Finally, if new knowledge is actively built, then time is needed to build it. Ample time facilitates student reflection about new experiences, how those experiences line up against current understandings, and how a different understanding might provide students with an improved (not correct) view of the world.

If learning is a constructive process, and instruction must be designed to provide opportunities for such construction, then what professional development practices can bring teachers to teach in student-centred ways? Constructivist professional development gives

teachers time to make explicit their understanding of learning (e.g. is it a constructive process?), of teaching (is the teacher an orator or a facilitator, and what is the teacher's understanding of content?), and of professional development (for example, is a teacher's own learning best approached through a constructivist orientation?). Such professional development provides opportunities for teachers to test and develop their understanding. Training that affects student-centred teaching cannot come in one-day workshops. Systematic, long-term development that allows practice and reflection on that practice is required (Thomas and Jonassen, 1993).

It is also useful to remember the educator's maxim, "teachers teach as they are taught, not as they are told to teach". Thus, trainers in constructivist professional development sessions model learning activities that teachers can apply in their own classrooms. It is not enough for trainers to describe new ways of teaching and expect teachers to translate from talk to action. It is more effective to engage teachers in activities that will lead to new actions in classrooms.

The rapid development of increasingly powerful computer and communication systems has great implications for the constructivist approach to education. Information technology offers a tremendous amount of information, tools for creativity and development, and various environments and forums of communication within a learner-centred curriculum based on learner performance or research. New technology tools provide many opportunities for learners to build knowledge in an engaged setting (Thomas and Jonassen, 1993).

The Internet and its graphic window, the World Wide Web, have made vast amounts of information available in a timely fashion. Learners can initiate searches more and more independently using information technology. Educators can encourage searching and classification more readily in a technology-rich environment. Increasingly powerful software applications have put tools for interpretation and knowledge creation in the hands of learners of all ages and abilities. Word processing, desktop publishing, database and spreadsheet packages and web-authorising programmes have greatly enhanced learners' potential for expression. These computer-based tools have tapped into learners' multiple intelligence and enabled those with an aptitude in visual learning for example, to demonstrate knowledge and knowledge creation more effectively. Through the use of information technology, in some schools, educators are restructuring their classrooms so that learners can participate as producers (Thomas and Jonassen, 1993). For example, learners have the opportunity to draw

any type of graph of a function using graphical packages. Information technology has enhanced the opportunities for learners to communicate with others. Learners and educators can extend their dialogue beyond the physical and time constraints of the classroom using e-mails, listservs, and live chats. Electronic data archives, web sites and e-mails all allow for increasingly expedient collaboration between learners.

In conclusion, constructivism has made a significant contribution to educational theory and practice. Its implications for how teachers teach and learn to teach are enormous. If the efforts in reforming education for all students are to succeed, then we must focus on students. To date, a focus on student-centred learning may well be the most important contribution of constructivism.

2.2.2 LEVY VYGOTSKY'S THEORY

Levy S. Vygotsky is best known for being an educational psychologist with a social cultural background. The social cognition model asserts that culture is the prime determinant of individual development. Humans are the only species to have created culture, and every human child develops in the context of a culture.

Vygotsky stated:

“Every function in the child’s cultural development appears twice: first, on the social level, and later on the individual level, first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logic, memory, and to the formation of concepts. All higher functions originate as actual relationships between individuals.” (Vygotsky, 1978, 213)

Therefore, a child’s learning development is affected in ways large and small by the culture, including the culture of family environment in which the child is enmeshed. Learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Thus, learning could occur through play, formal instruction, or work between a learner and a more experienced learner.

Levy S. Vygotsky's (1978) theory has impacted on learning in the following ways:

Curriculum: Since children learn much through interaction, curricula should be designed to emphasize interaction between learners and learning tasks. Computers as an instruction tool can play a vital role.

Instruction through the use of computers: With appropriate adult help, children can often perform tasks that they are incapable of completing on their own. With this in mind, scaffolding, where an adult continually adjusts the level of his or her help in response to the child's level of performance, is an effective form of teaching. Scaffolding not only produces immediate results, but also instils the skills necessary for independent problem solving in the future.

Assessment using computers: Assessment methods must take into account the zone of proximal development. What children can do on their own is their level of actual development and what they can do with help is their level of potential development. Two children might have the same level of actual development, but given the appropriate help from an adult, one might be able to solve many more problems than the other. Assessment methods must target both the level of actual development and the level of potential development.

Vygotsky (1978) introduced the idea of the zone of proximal development in which the educator, learner and content interact with a problem which needs resolution. Vygotsky also called the difference between what a child can do with help and what he/she can do without guidance the zone of proximal development. According to Vygotsky (1978), the zone of proximal development is defined as the distance between the actual developmental level as determined through independent problem solving and the level of potential development as determined through problem solving under the guidance or collaboration with more capable peers.

For a zone of proximal development to be created, there must be a joint activity that creates a context for learner and expert interaction. According to Vygotsky's theory of the zone of proximal development, the window of learning for an individual learner might be a narrow one. In my opinion, computer programmes were designed to help the learners reach their

potential in their zone of proximal development in many ways. The computer can be programmed to test various zones. For example, tests can determine the learner's ability to solve problems in a subject independently versus their level with assistance. The computer can also prompt learners and aid them in problem solving.

In addition, the computer can be the requisite social component for expert interaction. The only inequality between partners should be in their level of understanding. The computer can dissolve the social inequalities that exist between an adult instructor and learners. Vygotsky (1978) believed that partners should jointly solve problems to bring about cognitive development. The computer can pose problems and prompt learners to serve as the advanced partner to aid in problem solving.

Learning and development is a social, collaborative activity. Crook (1994) shared the same sentiments expressed by Vygotsky in the use of computers to teach children at kindergarten. According to Crook (1994) collaboration was central to the cultural approach in the same way that computation is central to the cognitive tradition and construction to the constructivist tradition. Collaboration for cultural theorists generally appears to mean that the educator provides a structure of support for learners who are aiming at achieving a goal (knowledge).

Crook (1994) analysed the variety of different ways in which Information technology can be part of the collaborative experience of learning. He distinguishes five different categories. These are:

- **Collaboration with computers.** This is an idea that brings to mind a solitary individual sitting at a keyboard working on a computer program. But, collaboration with computers is the goal of making such programs in order to reproduce the social character of a face-to-face tutorial dialogue (Crook, 1994).
- **Collaboration in relation to computers** means that educator-learner interaction does not involve working at the computer, but means a kind of support. Discussing issues about computers in the classroom (or in a place where someone could find a computer) might be a good example.
- **Collaboration at computers** refers to times when small groups of learners work on the same computer activity at the same time. For example, two students working on the same task, such as drawing a picture using a Paint program.

- **Collaboration around computers** refers to learners working together more informally than when a small group is working at a computer on a common task. Crook (1994) says that material environments will facilitate a whole range of social interactions that can occur within them.
- Finally, **collaboration through computers** means collaboration through networks, including the Internet. In this category learners can communicate with other learners or educators on issues of interest. There are software programs, which allow the educators to send work to learners as e-mail attachments, and learners can do the work and send it back for marking. The latter can take place without the learner or educator leaving the program. An example of such a program is the Markin. In as far as the Markin program is concerned, learners submit their work as e-mail attachments or word processing documents, and the educators will mark and return this document as quickly as they are submitted on paper. The advantage of Markin is that it breaks the physical barriers between learners and educators. Programs such as Markin have not yet been developed in the Republic of South Africa

One more conceptual axis of Vygotsky is that out-of school experiences should be closely related to the experience gained at school. It is important to mention here that in Vygotsky's study on computers, that is "Introducing computers to kindergarten children", computers emerged as tools that increased children's self esteem and attitudes and made children feel happy about new technologies and computers during teaching. The National Curriculum of South Africa puts a lot of emphasis on the use of appropriate technology, for example computers to demonstrate mathematical concepts.

2.2.3 JEAN PIAGET'S THEORY (1896 – 1980)

Jean Piaget, a Swiss developmentalist, began a research program during the 1920s that has had the greatest impact on contemporary theories of cognitive development than that of any single researcher. He developed his cognitive theory by actually observing children. Using a standard question or set of questions as a starting point, he followed the child's train of thought and allowed the questioning to be flexible. Piaget believed that their spontaneous comments provided valuable clues to understanding children's thinking and how children learn. He was not interested in a right or wrong answer, but rather what forms of logic and reasoning the child used (Singer, 1978). After many years of observation, Piaget concluded that intellectual development is the result of the interaction of hereditary and environmental

factors. Information technology can provide the requisite interaction environment. As the child develops and constantly interacts with the world around him, knowledge is invented and reinvented. An important component of contemporary theories is Piaget's proposal that for learning to occur, an individual must assimilate new information into existing cognitive structures. This means that there must be overlap between a new experience and prior knowledge. In addition, Piaget identified four stages in cognitive development according to (Huilit and Hummel, 2003). These stages are

Sensorimotor stage (Infancy 0-2 years)

In this period (which has six stages), intelligence is demonstrated through motor activity without the use of symbols. Knowledge of the world is limited (but developing) because it is based on physical interaction or experiences. Children acquire object permanence at about seven months of age (memory). Physical development (mobility) allows the child to begin developing new intellectual abilities. Some symbolic (language) abilities are developed at the end of this stage.

Preoccupational (Toddler and Early Childhood 2-7 years)

In this period (which has two sub-stages), intelligence is demonstrated through the use of symbols, language use matures, and memory and imagination are developed, but thinking is done in a non-logical, non-reversible manner. Egocentric thinking predominates.

Concrete Operational (Elementary and Early Adolescence 7 - 11 years)

In this stage (characterized by seven types of conservation: number, length, liquid, mass, weight, area and volume), intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects. Operational thinking develops (mental actions that are reversible). Egocentric thought diminishes.

Formal Operational (Adolescence and Adulthood 11 - 15 years)

In this stage, intelligence is demonstrated through the logical use of symbols related to abstract concepts. Children are able to reason hypothetically, to take into account all the

logical possibilities to analyse one's own thinking. They can construct experiments to test hypotheses systematically.

Duration or rate of succession of stages, accelerations or delays in the average chronological age of performance depends on specific environments (for example, abundance or scarcity of possible activities and spontaneous experiences, educational or cultural environment). The latter can accelerate spontaneous development, but cannot change the order of the constructions.

2.2.3.1 PIAGET'S THEORY AND THE USE OF INFORMATION TECHNOLOGY

Computers change not so much the nature of the discipline as its scale. Computers are to mathematics what telescopes are to Science. The use of computers, in Australia, in the teaching of mathematics has enabled learners to understand some mathematical concepts even those beyond their cognitive development (Australian Education Council, 1991:6).

The role of information technology in childhood education is a controversial topic, and both parents and educators have concerns about the potential benefits or harm to children. Critics contend that technology in schools wastes time, money and childhood itself by speeding up the pace and cutting down on essential learning experiences (Cordes and Miller, 2000). Proponents suggest that children should have the advantages that new technology offer. There is also some concern that modern technology is not being used in the best ways, or obtaining the expected results (Healey, 1998).

Both critics and proponents of computers in the classroom agree on the importance of the early years in a child's physical, social-emotional, language and cognitive development. The multi-million dollar questions are, "Are computers being used to enhance and hasten cognitive development, or are they detracting from and inhibiting intellectual growth in some way. Can technology support the specific needs of children or does it take away from essential development experiences?" (Healey, 1998).

Recent research on brain development has focused attention on the capabilities of young children, the stages and styles of learning, social-emotional development, and successful educational practice. Such research has argued that children lack knowledge and experience

but not reasoning ability, and that the appropriate stimuli such as close interaction with caring adults and engaging in hands-on activities, enhance the brain's development (Healey, 1998). A study by the National Research Council (Bransford, Brown and Cocking, 1999) state that Early learning is assisted by the supportive context of the family and the social environment, through the kinds of activities in which adults engage with children.

The influence of Piaget's theory is evident in latter research and it is in considering their models of development that we can make some assessments about the significance of working with computers for children's learning.

Research has attempted to apply the developmental theories to children's computer usage. In considering the Piagetian tasks of classifying and categorisation, Healey (1999) has made some interesting observations about computers and cognitive development. Healey (1999) maintains that a child sorting out groceries in the kitchen is developing skills and grasping abstract concepts differentiating between fruit and vegetables, household products and food, the different ways to sort these items, etc.) This three-dimensional, physical experience is qualitatively different from that of a child who is playing a categorisation game on a computer. Whilst both may be helpful, too much substitution of icons for "touch and feel" physical learning leaves something essential out of the developmental equation. Healey (1999) also asserts that spontaneous play and games with older children and adults are far more likely to enhance the brain development of children than the time spent on computers. The latter supports the views of Vygotsky and Bruner in terms of peer interaction and scaffolding. Indeed, Healey (1999) states that the best results from all information technology use for children who are accompanied by a skilled adult coach who adds language, empathy and flexibility.

Other research points to a list of possible positive effects of computer use. These include the relatively more abstract or complex proposed cognitive outcomes that include increases in creative thinking, problem solving skills, decision making abilities, the understanding of cause and effect relationships, and the ability to engage in Piaget's symbolic representation (Goodwin and Goodwin, 1986).

Others have cited the benefits to memory that come from computer use. Hoyles (1990) states that opportunities for developing children's memory skills can also be found in computer memory activities.

Hoyles (1990) believes that the sorts of representational tasks that computers require aid children in encoding experiences into their memories and actually remembering them. The early use of computers to aid instruction was based on the work of behaviourists such as Skinner, with computers providing drill and practice on previously learned skills, and the stimulus – response interaction between student and technology was the dominant paradigm.

However, research has warned that children need to be at the concrete operations stage before they are ready to use computers. Some of the specific skills that are considered necessary for computer use (not usually demonstrated by pre-operational children) are basic arithmetic skills, sequencing ability, and memory. (Goodwin and Goodwin, 1980).

The most influential of those attempting to apply Piaget's theories to children's usage was Papert, who saw in the computer the possibility for radically subverting the traditional methods of education. Papert (1980) believed that children as learners have a natural curiosity to construct meaning of their world and he saw the educational system too structured, stifling this natural curiosity. Papert (1980) maintained that the means by which children were being taught relegated them to a role of passive recipients of teaching and, as such, they were not motivated to construct any learning for themselves. His desire to have children become motivated learners, critical thinkers and problems solvers was to be achieved through educational reform, thus providing the learner with the necessary tools to participate and to take ownership of the learning process. According to Papert (1980), the computer was the appropriate tool to achieve this reform. He helped to design LOGO, a programming language for children with many powerful features, including 'turtle graphics'. Papert (1980) claimed that LOGO could benefit children's thinking and encourage exploration within an environment, so offering them a key to understanding. The turtle serves as an object to think with and LOGO provided the environment, which Papert called 'Mathland', where speaking the language of mathematics becomes second nature (Papert, 1980). Papert's claims for LOGO are not restricted to mathematics and he maintains that the act of programming the computer helps to develop skills, such as that of breaking down problems into manageable units, which can then be applied to other situations.

Contrary to Papert (1980), Hughes (1990) asserts that programming in LOGO does not in itself result in enhanced problem-solving capabilities, but cognitive gains are more likely to be observed when an educator carefully structures the experience. Whilst most evaluation of the impact of LOGO has focused on individual cognitive skills, it has become apparent that working with LOGO opens up possibilities for social interaction (Clements and Nastasi, 1988).

Papert's (1980) contention was that the potential of the computer in aiding development lay not in its use as a tool for educators, but on the contrary, its potential lies in extending children's control over their own learning (Light, 1993).

2.2.4 JEROME BRUNER'S EDUCATIONAL THEORY

Jerome Bruner was a psychologist whose name is closely associated with curriculum reform of the 1960's. Bruner was a structure-oriented educator, one who believes that mathematics is best learned by teaching the basic concepts and principles that give coherence, i.e. structure to mathematics. The focus of structure-oriented teaching is to use methods and materials, in the form of teaching aids that will promote meaningful conceptual development. The use of information technology as an instructional tool can be used to support Bruner's educational theory. Bruner's theoretical framework centres on providing a learner with concrete experiences of a concept, which will enable the learner to develop mental representations and finally allow the learner to move to a symbolic representation of the concept and be able to transfer the knowledge to new problems and situations. Information technology can be an effective instructional tool when it comes to concrete experiences.

Bruner believes there are four aspects of teaching and learning mathematics. According to Bruner (1966), the four aspects are unmasking, intuition, translation and readiness.

Unmasking consists of discovering certain properties or patterns that may characterise solutions of problems. Bruner says that if learners are given opportunities to discover mathematical concepts on their own, they develop the "A-HA" feeling and come to view the act of discovery as the reward for their work. Manipulation and representation in continuing cycles are necessary for discovery. Information technology and its software packages can

assist learners in the representation of mathematical concepts. The second aspect of teaching and learning mathematics is the intuition mode, which is grasping the concepts of mathematics without reliance on formal rules or definitions. The third aspect Bruner discusses is translation, which involves the translation of intuitive ideas into mathematics. In order for mastery of a concept to have occurred necessary sequences or steps must have occurred. The fourth concept is that of readiness, Bruner (1966) states that one teaches readiness or provides opportunities for its nurture; one does not simply wait for it.

In the latter, the assertion is that learners are ready to learn about anything at any time, provided that educators scale the information down to a level the child can understand. The active representation of mathematical concepts is the doing, the action and the hands-on stage of learning. For example, the learner can sit on the beam, a teeter-totter, and observe how persons of different weights can balance the beam by changing their positions on the beam. The children can rock, trade places, stand, and lean backwards, or do anything that gives them a feel for the concepts of balance. Using appropriate software the concept of balance can be illustrated by means of computer graphics (Bruner, 1966).

In conclusion, the basis of structure-oriented teaching is to convey mathematics in a meaningful way while taking into account the cognitive abilities of the learner. Structure-oriented methods have not demonstrated their own validity largely because the psychological tools needed for evaluation are only now becoming available.

2.3 COMPUTERS AND MATHEMATICS EDUCATION – EXAMPLES OF SOFTWARE

With the introduction and application of technology in the secondary mathematics curriculum in the United Kingdom, predominantly in the form of computer software, a new dispensation has emerged (Dix, 1999).

The following section deals with examples of specific software used in the teaching and learning mathematics.

2.3.1 MARKIN SOFTWARE

Markin is one of the latest software technologies, which can be used in the teaching of mathematics. This new technology requires new tools and educators working on-line, it needs facilities, which are just not available in a standard web browser or word processor. Learners submit their work as e-mail attachments or word processing documents, and educators need to be able to mark and return these documents as quickly and as easily as they can mark work submitted on paper. Markin is one of the latest marking and assessment software for an on-line and electronic teaching environment. It can import text material from a clipboard or text file and provides all the tools you need to mark this text. When finished, an educator can export the marked text as a web page so the learners can view the marked text in a browser or can e-mail this file directly to the learner, all without leaving the Markin program.

2.3.2 TEXT TOYS

Text toys is a suite of two authorising programs, Web Rhubarb and Web Sequitur. These programs are used to create web pages in Hyper Text Markup Language (HTML – allows the user to link to another site by using the highlighted text) documents, which contain interactive language learning exercises, which are based on the Rhubarb and Sequitur programs originally developed by John and Murriel Higgins. Once the exercises have been created they can be delivered to the learners in the form of web pages.

2.3.3 SHACK'S MATH PROBLEMS

Shack's mathematics problems are a web page of mathematics problems ranging from basic mathematics to differential equations. Shackleford (2001) designed the mathematics problems. Each problem comes with a difficulty rating from one to four stars. This is roughly a measure of how much time it will take a learner to do the problem. For each problem asked, a solution or answer is provided. This will enable learners to assess themselves. The advantages in the use of information technology for assessment are more frequent formative and summative assessment; educators can be alerted sooner to adapt their teaching; educators spend less time marking; increased learner confidence; learners like rapid results and self assessment in the learner's own time and pace (Alter, 1993).

2.3.4 MATHPLUS

MathPlus – is a new improved Windows version of Theorist, a computer–algebra package that has been available for the Macintosh for several years. MathPlus has over 250 built in mathematical functions with instructive live notebooks illustrating finite and infinite series laplace transforms, 3-D graphics and more (Gager, 1996).

2.3.5 BREAKAWAY MATH INTERACTIVE CD-ROM

Breakaway Math Interactive CD-ROM – is a learning package intended for use by learners aged between 7 to 12, but with a content level of 1 to 3 of the UK National Curriculum for Mathematics. It is suitable for learners who are known to be experiencing some difficulties with basic mathematical concepts. (Harling, 1996). The following software make up the Breakaway Math Interactive CD-ROM.:

2.3.5.1 GRIDPRO

GridPro – is advertised as being a sophisticated grid–drawing package invaluable to any secondary school mathematics lesson or indeed any subject that might need customised graph paper. This package has a number of points in its favour including the ability to draw almost any kind of graph or tessellation on paper, the ability to save and recall any one of them in a moment's notice and the ability to print the chosen grid on any size of paper (Leacy, 1995).

2.3.5.2 COMPUTER GAMES

Computer games – are prolific, although many are not appropriate for the teaching of mathematics. An intrinsic aim of all these might be to familiarise learners with the computer. At least three types are valuable mathematically

- Those which give rise to the practice or reinforcement of skills and concepts.
- Those which encourage the use of strategies.

- Games, which involve scoring. Such games can be useful both for developing mental arithmetic skills and giving learners access to and experience big numbers. War games often involve large numbers (Oldfield, 1991).

2.3.5.3 TRIG PAK

Trig Pak: software and Tutorials for Trigonometry (Mowbray, 1989) says, this is a wonderful mathematical environment. The function plotter is easy to use and does an excellent job. A trigonometric function is plotted, and the user must enter the rule for the graph in the form of $y = a \sin b(x + b)$, this module gives the learner the much needed opportunity to experiment with and investigate trigonometric functions. The Trig Pak includes an on-line help system.

2.3.5.4 CLOCK SHOP, COIN CRITTERS, PRE-SCHOOL PACK AND TURBO MATH FACTS AS SOFTWARE EXAMPLES

In their article (Battista and Clements, (1994), a number of computer materials have been outlined. These computer materials can be applied to the teaching of mathematics and most of them are user friendly. The computer material includes: Clock Shop – a game used to help learners practice reading and writing time; Coin Critters – which allows learners to practise using coins of the United States monetary system; Pre-school Pack- allows learners of the pre-school to manipulate shapes of different sizes and Turbo Math facts – which is a tutorial program designed to tutor learners in the arithmetic skills of addition, subtraction, multiplication and division.

2.3.5.5 TOM SNYDER PRODUCTIONS

A very popular software in Denmark which can be used in technology-based simulations that focus students on real life problems. Teachers act as mediators or facilitators. Technology manages student decisions, while the educator focuses on heightening student interaction.

2.3.5.6 AUTOGRAPH

A valuable piece of software that can be used for worksheets and examination papers. It makes beautiful graphs of a number of algebraic functions.

2.3.5.7 THE GEOMETER'S SKETCHPAD

This is particularly important for learners who struggle to visualise and understand geometrical problems

Countries like the United Kingdom, have introduced the concept of Science and Engineering Ambassadors (SEAs). The aim of the SEAs is to encourage more young people to understand the opportunities that are offered by science, engineering or technology-based careers. Mathematicians, scientists, engineers and other technical people will be working with schools on a voluntary basis. These ambassadors will build on existing initiatives to provide schools with access to high quality resources and exciting activities (Battista and Clements, 1994).

In mathematics these SEAs can be used to bridge the gap between mathematics and technological issues especially the industrial ones. The United Kingdom has introduced 'The New Category of Specialist School on mathematics and computing science,' whose main aim is to further the application of computers to mathematics and to promote the development of more positive attitudes towards the acquisition and application of mathematical knowledge and understanding.

2.4 RESEARCH ON THE USE OF INFORMATION TECHNOLOGY IN MATHEMATICS EDUCATION

Johnson's research focused on the learners' learning and classroom activity involving information technology in school subjects; mathematics, science, geography and english. This research was carried out in the United Kingdom. He then concluded that

- Computers were found to be good motivators, which heightened learner's interest and enjoyment and were also seen to have a positive effect upon the status of the subject.
- Opportunities to work in an open-ended way enable learners to become involved in more complex and challenging situations beyond that typically experienced.
- Computers aided concentration by focusing learners' attention on the work in hand. As a result some learners and educators believed that the standard of work produced was of a higher quality than it would have been otherwise. Johnson (1994) also acknowledges that the failures to detect the contributions through the use of information technology may be attributed to some of the problems encountered by

learners like

- Difficulties in using particular software package.
- Inability to work effectively in a collaborative environment.

Higgo (1994) echoed the same sentiments which Johnson (1994) had on the use of technology in the teaching of mathematics. However Higgo (1994) is somehow concerned about the assessment of learners' work in mathematics after they have used computers to do their work. In other words, educators may fail to distinguish between the learner's knowledge on computers and his/her mathematical skills. The British National Curriculum includes several helpful references to the use of computers, but, because there is not a written test (nor, indeed, much encouraged any longer in coursework), many secondary mathematics departments still manage to avoid using computers at all. They use the argument, for example, that database work is done within the technology curriculum anyway. Scientists have developed several computer packages, which can be used by learners to enhance their mathematical skills and their understanding of mathematical concepts. These packages have proved to be very popular with mathematics learners at all levels of education, that is, primary, secondary, college and universities. Apple (1987), the eminent educational sociologist argues strongly that this notion of the computer ethos replacing the educator's ethos is dangerous for society.

A few school in South African began using computers about twenty years ago, at the same time as computers began to appear on secretaries' and managers' desks down town (Paul, 1998). The early machines (the BBC 'B', the commodore, the Sinclair, the Apple II and IBM P.c. etc.) were unsophisticated by today's standards. The limited word processing, spreadsheet and database packages on offer were crude and somewhat unfriendly, forcing many to learn BASIC and other high level programming languages in order to get the machine to do specific tasks. Computing was essentially text based and getting around one's machine required one to learn dozens of cryptic commands for example (dir a:/w/p. cd/ and type c:/my lettal.doc). The features we take for granted today, such as colour and easily available graphics, were hinted about but undeveloped, while CD-ROM based encyclopaedias, electronic mail and the web were unheard of. However, there was a palpable sense of excitement about personal computing and an overriding belief that research at least had a tool which would revolutionise teaching and learning, a tool that would enable teachers

and children to do new things and to do existing things better and more efficiently (Paul, 1998).

Hawkrigde (1990) cited in Paul (1998) identified and described four main rationales for the use of computers in South African schools. These are

➤ **The social rationale**

The social rationale suggests that all children should be aware and unafraid of how computers work. Because computers play an increasingly important part in modern life and because schools are supposed to prepare children for adult life, it follows that schools should provide some measure of computer awareness.

➤ **The vocational rationale.**

This rationale suggests that children should learn to operate computers because learning to programme gives children confidence in the ability to control computers. Learning how to use application programmes (word processing, spreadsheets etc.) provides skills that will be needed later in life. Computer Literacy and Computer Science should be offered at schools.

➤ **The pedagogic rationale**

This rationale is based on the belief that computers are able to teach. Computer aided learning and computer aided instruction offer certain advantages over traditional methods.

➤ **The catalytic rationale**

The belief here is that computers can change education for the better. Managerial, administrative and teaching efficiency can be improved. The use of computers enables teachers to place more emphasis on important problem solving approaches rather than tedious rote learning and calculation. Computers give both learners and educators more independence collaborative learning rather than competitive learning can be stressed.

The latter rationales may vary from person to person. However, the idea of computers improving teaching and learning has gripped the imagination of educators world wide. The idea of enriching the curriculum, improving delivery, extending traditional methods

of presenting information and offering new opportunities through the techniques that computers make possible is very exciting. The catalytic rationale has the most potential and supporters of this rationale see computers providing children with the opportunity of moving away from rigid curriculum, rote learning and teacher centred lessons by giving more control to children to do their own learning.

Paul (1998) on "How do we use computers in schools," acknowledges three basic ways of using computers in South African schools. These are

➤ **The computer as tutor**

Here tutoring systems present subject material, to which the learner responds. This type of material is programmed by specialists and includes drill and practice exercises and tutorials. This kind of program varies widely, from simply repetitive to sophisticated tutorials which keep check of progress and suggest areas of remediation.

➤ **The computer as a tool**

Tools include software like word processing, spreadsheet, databases, presentation software, and desktop publishing to name a few. They are generally curriculum free, in that they can be applied to a wide variety of educational and other activities.

➤ **The computer as tutee**

Tutee systems are regarded by some as the most powerful in that they allow the learners to control the computer. An example is using high level programming languages like LOGO and Visual Basic.

The reasons why computers were not used in schools in East London in South Africa according to Paul (1998) are

- The majority of teachers felt inadequately prepared to use technology resources, particularly computer based technologies.
- Much of the teacher development activity focused on mechanics, not on integrating technology into the curriculum.

- Teachers lacked an understanding of curricular uses of technology and were unaware of the resources technology can offer them as professionals in carrying out many of their jobs.
- A shortage of computers because of the high cost of hardware and software.
- Poor placement of existing resources in laboratories where they are difficult to access.

As part of a solution for the latter problems, Paul (1998) suggested that

- Providing effective professional development to educators would seem to be a good starting point.
- More thought needs to be given to design a curriculum, which makes full use of computers across and as part of the curriculum.
- Computers should be placed in the classroom where they are readily available, rather than in the laboratory.
- Educators and other stakeholders should have faith and patience. Change will not occur over night.
- Educators should read educational journals, which deal with educational computing to enhance their knowledge on the use of computers.

Kulik (1994) in Sewell and Burger (1999), made the following three points in connection with the use of computers in the learning and teaching of science in South Africa. These are

- Students usually learn more in classes in which they receive computer-based instruction.
- Students learn their lessons in less time with computer-based instruction
- Learners like their classes more when they receive computer help in them.

However, Sewell and Burger (1999), have acknowledged the difficulties of integrating computers into teaching and learning in schools. Their reasons for these difficulties include the following.

- Teachers lack experience and they lack the time to learn how to use hardware and software. Teachers are inadequately trained to use computers in their classrooms.
- Computer technology is seen as peripheral to the curriculum and is given very little space in an ever-expanding and demanding curriculum.

- Students and teachers do not have adequate access to computers. This is either because the student to computer ratio is too high or because the computers are physically inaccessible, for example, housed in a computer laboratory remote from learners.
- Educators fear change. Generally, learning environments are curriculum centred and not learner centred. In the classroom, where the role of teacher is that of dispenser of knowledge, computers are used mainly for word processing and drill and practice. Many educators do not integrate computers into their curriculum because they feel threatened either because they feel insecure with technology or because they fear that the computer will expose their lack of subject knowledge.

Since 1994, South African education policy has supported the integration of technology into education. However, statistics reflect that policy projections have yet to be actualised, and the majority of South African schools are presently not able to comply with the aims for school technology as stated in Education Department documents (UWC, 1998). One of the main reasons for this deficit is that policy decisions are taken at a national level, whereas their actual implementation is technically the responsibility of the provincial education departments, which differ widely in terms of expertise and capacity. This has led to disparities in the integration of computers in schools between and even within different provinces.

The aims of South African Outcomes based curriculum 2005 (Education Department, 1997a) emphasises:

- Individualised hands-on learning
- Teamwork and,
- Guided discovery of information.

Although South African government policy advocates the integration of computers into schools, this policy now needs to be implemented by education departments at a national and provincial level. This requires national planning and management of informed computer agenda including

- Technological investment in infrastructure and support.
- Incorporation of computer-based skills into curriculum objectives.
- The development of new curricular materials.
- Extensive teacher training in the use of computer assisted education in the classroom.

In conclusion one can say that there is an enormous shortage in the South African industry of people with technological education. The foundation stone on which we must build to address this problem is the training of educators in technology education. These educators will help bring about change in our education system.

2.5 CHALLENGES OF USING INFORMATION TECHNOLOGY

When educators use technology as a critical part of an inquiry-oriented learning process, there are several challenges. Educators need to learn to use a variety of technological applications. When we think of educators learning to use a variety of technology applications, we tend to focus primarily on their need to learn how to operate hardware and software. Although this is a critical component, educators also need to learn how to develop a method of keeping abreast of new technologies and find out about the potential power each technology application has with respect to inquiry-based teaching and learning. Each new application brings new benefits and new problems to be solved. For example, although electronic networks are opening the classroom to new learning for both educators and learners, this medium brings new challenges for educators (Education Reform, 1993). Research has also shown that it is very difficult for educators to sustain regular, substantive discussion on a network, hence, the discontinuity in the conversation can be a big disadvantage because if some questions go unanswered, a request is ignored, or interesting lines of discussions are not pursued, the conversation may falter and users may drop out. The latter will give rise to a new challenge for educators, which is the adaptation of educators to a new role of a facilitator when using information technology (Educational Reform, 1993).

These computer-supported inquiry programmes also require advanced educator skills in integrating technology into inquiry learning. Beyond “procedural knowledge” of the software, educators need “conditional knowledge” of the contexts and situations in which the tools are appropriate and the ability to recognise those situations as they arise. For example, when learners are beginning to generate related ideas for their topic, the educator needs to recognise at that moment the contribution a software-mapping tool like inspiration might make to the learners’ organisation of ideas.

Responding to individual learner needs can present a big challenge to educators. Many

technology software applications, for example, text browser, word processing and databases, offer educators a window into the learner's thinking inquiry and problem-solving process. When the work learners are doing is visible on a monitor or printout, educators have access to the learners' misconceptions, the ways in which the learners sort and categorise information, the relationships they form between ideas, and the conjectures they make. In an educator's view, a learner's response may not be the most logical, appropriate, or even "correct" response. However, trial and error is part of problem solving. Educators are often tempted to intervene too early or too often, being motivated by their genuine desire to set a number 'on the right track' and to avoid floundering. This tendency can be exacerbated by the public character of the computer monitor, which makes the learners more visible and accessible to intervention by the educator at all stages as compared to the more private medium of paper and pencil. Intervention in learners' work at an early stage can be helpful, but it can also thwart the learners' reorganisation of ideas, thereby short circuiting their construction of knowledge (Hopkins, 1991).

Many of the technology applications imply a broader and deeper knowledge of the discipline than may be required by the curriculum that assumes educators transmit a fixed body of information. The challenge is that for the educator to be successful he or she must know the subject matter, function as a leader and manager of a community of learners, be flexible and have time for planning and preparation throughout the year. Research findings of high school educators in United Kingdom have concluded that educators need a deep and wide knowledge of their subject matter and a clear understanding of the process of building mathematical understanding in order to use the software effectively (Wiske, 1990).

Providing adequate technology access is one of the challenges faced by schools, institutions and colleges in developing countries. Technology cannot become a meaningful support for learners' work if they have access to it for only a few minutes a week. The kind of technology-supported subject-based instruction advocated in the research study requires a high level of access to the technology tools that learners use on a daily basis to support their work. A corollary to the challenge of providing adequate access to technology generally is the concern of making sure that different kinds of learners get equal access. Data from national surveys in South Africa suggest that learners' from low-income homes are less likely to have computers in their homes. In the United States of America, although these differences are smaller than those for ethnicity and socio-economic status, there is also a gender

difference in technology access to computers, with boys having more home access to computers than girls (Sutton, 1991).

Even after educators' initial fear of getting involved with technology has been overcome, serious challenges remain in terms of providing enough technical support that educators will not be discouraged by equipment failures or software behaviour they do not understand. Substantial technical support is needed in schools where all or most educators use technology particularly if new or experimental systems are involved or extensive use is made of computer networks. There are at least five kinds of technical assistance which are necessary helping in the planning for technology uses and acquisitions providing training in how to use new hardware and software providing demonstrations and advice on how to incorporate technology into instruction providing on-demand help when software problems or hardware failures arise and performing low-level maintenance on the system (Education Reform, 1993).

The effects of computers on learners' physical and social development can also be significant. The amount of time and the type of activities that learners engage in whilst using computers are key factors influencing whether technology has positive or negative results on their development. Reports warn that learners suffer repetitive strain injuries and damage to vision from extended use of computers. Working with computers can be a socially isolating experience and affect the child's ability to interact with other human beings. Children spending substantial amounts of time on-line, communicating with strangers in multi-user domains and chat rooms, have been found to experience greater declines in social involvement and increases in their feelings of loneliness and depression. Similarly, exposure to violent computer games has been linked with increased aggression and antisocial behaviour. The latter underline the importance of supervised use of computers, both in the classroom and at home, and the guidance of an adult to encourage children to use computers in appropriate ways.

Another socio-cultural challenge around the use of computers in the classroom is that pre-existing patterns of social inequality may be worsened, particularly in terms of gender. It is feared that there is potential with educational computer technologies to place girls at a disadvantage to boys since girls use such technology less (Hoyles 1990). However, whilst there is evidence that there are gender related differences in terms of attitudes, frequency of

use and type of use of computers, these differences are not generally associated with performance on computer tasks.

A study by Underwood and Underwood (1990) suggests that girls perform just as well as boys when they engage with computer-based tasks and programming activities. A number of explanations have been offered to explain gender differences, one of which proposed that they are linked to the issue of individual versus collaborative modes of working. The challenge to the educator is how he/she is going to make sure that both boys and girls have equal access to the technology at their disposal. Hoyles (1990) found that when computers are used individually, girls tend to find the experience isolating, thus reducing their performance. Hoyles (1990) did his research in the United Kingdom. However, when the computer is associated with a collaborative mode of working, girls are typically as eager as boys in their response and performance.

A study by Turkle (1984), in the United States of America, has concluded that there may be differences in the cognitive styles of boys and girls that affect the way in which they relate to computers. Working with computers today requires formal analytical skills, which evidence are masculine skills. If this were true, girls would need to be helped to overcome social conventions and to adopt approaches to computers using their own strengths and cognitive skills. It may also be significant that the metaphors and images used in the presentation of a task are more suited to boys than girls, and that context exerts a critical influence on cognitive performance and its relative difficulty for the different sexes. Like in most spheres of life, gender issues can be a big challenge when it comes to the use of information technology as an instructional tool to teach mathematics.

Haugland (1992) carried out studies in the United States of America, in which children exposed to non-developmental software had significant losses in creativity, whilst children exposed to developmental software had significant gains in intelligence, non-verbal skills, structural knowledge, long-term memory and complex manual dexterity. Therefore, for any computer software to have a positive influence on cognition and education it needs to be developmentally appropriate, otherwise it is liable to cause damage. Therefore, the challenge for educators is to provide learners with the most appropriate and relevant software.

2.6 CONCLUSION

Although technology poses many challenges for educators, it is a powerful tool for supporting the educator's work. Technology is making it possible for educators to break out of their traditional isolation, communicating with outside content experts and their peers about instructional content and pedagogical issues that are at the heart of their work, and communicating with parents about expectations, activities, assignments, and learner progress.

Computers can be used in developmentally appropriate ways that are beneficial to children, or they can be misused, just as any other materials may be misused. Furthermore, just as pencils do not replace crayons, but rather provide additional means of expression, computers do not replace other methods of learning, but add to the tools available to children to explore and communicate. When used appropriately by skilled educators, information technology can support and extend learning opportunities. The key is finding the balance between the relevance of a software package and knowing how to align the elements of a healthy childhood with the unique capabilities offered by information technology in teaching mathematics in schools.

3 CHAPTER THREE: METHODOLOGY

3.1 INTRODUCTION

In this chapter, all aspects pertinent to the methodology and research design of the research study are described and analysed. These aspects include answers as to what type of methodology was used, research population, research sample, research instruments and a discussion on the reliability and internal validity of the research study.

3.2 SURVEYS

The type of research used in this study was survey. Survey research involves describing the characteristics of phenomenon or groups by means of such instruments as interview schedules, questionnaires, and tests. The main goal of surveys is to provide facts and estimates that can be used by decision-makers to gain insight into understanding the relationship and differences of phenomena. A survey provides an understanding into the challenges and implications associated with the use of Information technology in the teaching and learning of Mathematics (Trochim, 2000).

The advantages of the survey method includes; ability to accommodate large sample sizes; ability to distinguish small differences; ease of administering and recording of questions and answers; I was capable of using advanced statistical analysis and it provided provisions for tapping into factors and relationships not directly measurable. However, the survey had the following disadvantages, for example development of accurate survey instruments; inaccuracies created in construct and scale measurements of factors; limits to the in-depth detail of data structures; difficulties in determining if respondents are responding truthfully and misrepresentations of data results and inappropriate use of data analysis procedures (Trochim, 2000).

In this research study, I chose to use a survey approach because it allowed him to get lots of structured information from educators and learners. By using survey research I was able to identify patterns of similarity and differences on the use of Information technology in the teaching and learning of Mathematics. The survey research method also proved vital in allowing me to elicit information on aspects that cannot be observed, such as; thoughts,

emotions, intentions and attitudes of educators on the use of information technology.

3.3 RESEARCH POPULATION

A research population refers to a group that is the subject of research interest (Goddard and Melville, 1996). The research population of this research encompassed high schools in the three districts of Mafikeng, Zeerust and Lichtenburg. The research population was made up of eighty-one high schools from the three districts. The findings of this study will be generalised to the Mafikeng, Zeerust and Lichtenburg districts of the North West Province of South Africa.

3.4 RESEARCH SAMPLE

A research sample is a proper subset or part of a research population. It is made up of a selected few items from the research population. In this research study forty-two educators were randomly chosen from eight high schools which were participating in the study. The targeted educators were teaching either mathematics or computer studies in their respective schools. The research sample also included one hundred and forty-four learners from eight randomly chosen high schools in the three districts.

3.4.1 DISTRIBUTION OF THE RESEARCH SAMPLE

The following table shows the summary of the distribution of the research sample. In order to protect the anonymity of the respondents, the letters A, B, C and so on are used to represent the schools that participated in the research study. Random selection was used to identify the schools which participated in the research sample of the study. Five educators from the randomly chosen schools automatically qualified to be part of the research sample. If the educators happened to be more than five in the school then random selection was used to identify only five educators.

DISTRICT	SCHOOL	NUMBER OF LEARNERS	NUMBER OF EDUCATORS
ZEERUST	A	24	5
	B	24	5
LICHTENBURG	C	24	5
	D	24	5
MAFIKENG	E	24	5
	F	24	5
	G	-	6
	H	-	6
TOTAL		144	42

Distribution of research sample

In summary eight schools from the three districts participated in responding to questionnaires, the research sample consisting of one hundred and forty-four learners and forty-two educators. From this targeted research sample, one hundred and twenty five learners and forty-one educators successfully responded to the questionnaires.

3.5 RESEARCH INSTRUMENTS

Permission was sought from the Superintendent General, Department of Education, North West Province to allow the research study to be carried out. There were two questionnaires. Questionnaires were composed of closed-ended questions. Closed-ended questions were supposed to provide more direct and factual responses. Closed-ended questions were structured according to the Likert scale on a five-grid system, that is; strongly disagree, disagree, undecided, agree and strongly agree.

3.5.1 QUESTIONNAIRES

Two questionnaires were used in this research study. One questionnaire was designed for educators and the other for learners.

3.5.1.1 QUESTIONNAIRE FOR LEARNERS.

The questionnaire for learners had two sections; Section A and Section B. Section A was intended to provide information on the demographics of the learners who took part in the research study. The type of data gathered from Section A addressed aspects such as type of school which learners came from, gender, age, whether mathematics and computer studies were part of their learning areas and whether the learners had computers at home.

Section B of the learners' questionnaire was intended to find out the perceptions of the learners on the use of information technology (computers) as an instructional tool in the teaching and learning of mathematics. Learners were supposed to classify their responses using the five grid Likert Scale using strongly disagree, disagree, undecided, agree and strongly agree. Section B gathered data on the use of instructional tools in the teaching and learning of mathematics; the use of computers as an effective instructional tool and the challenges faced by learners as they used computers to learn mathematics: In this Section B, learners also had the opportunity to point out how the educators could assist learners to use computers to learn mathematics.

3.5.1.2 QUESTIONNAIRE FOR EDUCATORS

The questionnaire had three sections; Section A, Section B and Section C. Section A was intended to elicit information on the personal details of the educators who took part in the research study. Educators were supposed to give information to the researcher on aspects such as their gender, academic and professional qualifications, position held in school, age and teaching experience, terms of service, subjects taught and the number of computers in their respective schools.

Section B of the educators' questionnaire was intended to find out their perceptions on the use of information technology as an instructional tool in the teaching and learning of mathematics in high schools. A five grid Likert Scale with categories strongly disagree, disagree, undecided, agree and strongly agree was used. In Section B information was gathered from educators on the use of information technology as an effective instructional tool. In this section educators were also asked to respond on the challenges they were likely

to face as they adopted a curriculum where information technology played a pivotal role in the teaching and learning of mathematics in high schools.

Section C of the educator's questionnaire was intended to find out what computer-based activities were used by educators when teaching mathematics.

The advantages of the questionnaire were:

- It was handy when resources and funding were limited. The questionnaire was quite inexpensive to administer. The administration cost per person of a questionnaire was as low as postage and a few copies. Time was also an important resource that the questionnaire minimised.
- Questionnaires were easy to administer confidentially. Confidentiality was the necessary component to ensure participants responded honestly. Examples of such cases included enquiries that needed to ask embarrassing questions about private personal behaviour.
- Questionnaires were used when corroborating other findings. In a study that had resources to pursue other data collection strategies for example interviews, questionnaires were a useful confirmation tool. More costly schemes could have provided interesting trends, but there were no resources to run these other tests on large enough participant groups to make the results statistically significant.
- Closed format questions offered many advantages in terms of time and money. By restricting the answer set, it was easy to calculate percentage and other hard statistical data over the whole group or over any subgroup of participants. Modern scanners and computers make it possible to administer, tabulate, and perform preliminary analysis in a matter of days. Finally, closed format questions allowed the researcher to filter out useless or extreme answers that might occur in an open format question.

The disadvantages of a questionnaire were:

- Closed format questions had several disadvantages. Firstly, their very nature did not allow the researcher to probe fully into the attitudes and feelings of the respondents. Secondly, quite a number of respondents might not have found any of the five grid system (Likert Scale) to represent any of their answers at all times.
- Questionnaires can suffer from the "form filling" syndrome, especially if administered via post. It is quite obvious that other researchers from the university had already visited the

high schools the researcher visited. Educators could have been subjected to several questionnaires; as a result they could have been fed up with responding to the questionnaires. In some quarters, it can be said that the neutral answer or in this research the “undecided” can be over utilized, especially by bored questionnaire takers.

- Questionnaires required a lot of time to design and develop. The questions from the questionnaires needed to be carefully constructed with the respondents in mind so that they measured exactly what they are intended to gather. A lot of thought was put into these questions in terms of the language and vocabulary used, thus avoiding the repetition of questions and occasionally boredom. A questionnaire is only as good as the questions it contains.
- Questionnaires limited the scope of questioning. Questionnaires were structured in such a way that they did not exhaust all the answers from the respondents.

3.6 RELIABILITY AND INTERNAL VALIDITY

The following section will deal with reliability and internal validity of this research study.

3.6.1 INTERNAL VALIDITY

Internal validity concerns the soundness of an investigation (Polgar and Thomas, 1997). Internal validity is the strength of our conclusions, inferences or propositions. More formally, Lock and Campbell (1979) defined internal validity as the best available approximation to the truth or falsity of a given inference, proposition or conclusion.

However in research studies there are threats to internal validity. Threats to internal validity limit the extent to which the researcher can conclude that the different outcomes observed in groups of subjects are due to the differential treatment administered to the groups. In other words, a study has poor internal validity if alternative explanations for the different outcomes cannot be ruled out.

3.6.1.1 THREATS TO INTERNAL VALIDITY

This section deals with the threats to internal validity of this research study.

3.6.1.1.1 INSTRUMENT ERROR

Instrument error refers to the accuracy or precision of a measuring instrument due to respondents failing to understand the questions. In order to counter the threats to internal validity in this research study, the researcher used valid and reliable instruments. In order to minimise the threat to internal validity on questionnaires the researcher ensured that all questions were clear, succinct and unambiguous. The goal was to eliminate the chance that the questions meant different things to different people. If the designers fail to do this, then essentially participants will interpret questions differently. A pilot test of the use of the instrument was also implemented to a group of learners and educators, which were not part of the research sample. The test group gave information on the interpretation of the questions.

3.6.1.1.2 SINGLE GROUP THREATS

Single group threats apply when the researcher studies a single group receiving a test. In the research study single group threats were absent because eight schools participated in the research study.

3.6.1.1.3 HISTORY THREAT

A history threat occurs when an observed effect might be due to an event which takes place between the pre-test and post-test; when the event is not of research interest at that time. This type of threat did not occur in this research study, since the pre-test and post-test were not part of the research study. Questionnaires were applied only once to participating respondents.

3.6.1.1.4 MATURATION THREAT

A maturation threat occurs when an observed effect might be due to the respondents changing with the passage of time. In this research study the maturation threat did not exist since the questionnaires were applied once only.

3.6.1.1.5 TESTING THREAT

A testing threat occurs simply when the act of taking a pre-test affects how that group does on the post-test. For example, if in a study of class participation, one measured class participation prior to implementing your attendance policy, and learners became forewarned that there was about to be an emphasis on participation, they may increase it simply as a result of involvement in the pre-test measure and thus, the outcome could be a result of a testing threat. Since there were no pre-test and no post-test in this research study a testing threat did not exist.

3.6.1.1.6 INSTRUMENTATION THREAT

An instrumentation threat occurs when an effect might be due to a change in the measuring instrument between pre-test and post-test or the increased participation could be due to the way in which the pre-test was implemented. In this research study there was no instrument change, hence this instrumentation threat was greatly reduced.

3.6.1.1.7 SELECTION THREAT

Selection threat occurs when an effect may be due to the difference between kinds of people in one experimental group as opposed to another group. In order to guard against selection threats this research had a research sample made up of Secondary school learners from three districts. Schools in the districts were identified through random selection.

3.6.2 RELIABILITY

Reliability is concerned with the accuracy of the actual measuring instrument or procedure (Ratcliff, 1995). To ensure reliability in this research study the structure of the questions of the questionnaires were in a way such that they complement each other. In other words the questions were such that they inquired for one thing in a different way. If the respondents of the questionnaires were consistent they may not give a 'yes' on one question then later on give a 'no' on the same content but different question. Internal validity is said to exist when the responses of individuals are consistent throughout the questionnaire. Asking different questions referring to the same content during interviews helped to probe whether the information received from the interviewees was consistent. This ensured validity of the research findings.

One of the strongest points in this research study was that it combined both quantitative and qualitative research methodologies. Qualitative research techniques were used to analyse research findings from interviews and questionnaires which could not be expressed in numbers. Whereas quantitative research techniques were used to analyse research findings from structured questions of the questionnaire which could be expressed in numerical form. Quantitative research techniques also allowed a comparison of perceptions between learners and educators. The latter, when merged or used in the same research, strengthened the internal validity of the research design. By combining the two methods, the advantages of each methodology complimented the other, making a stronger research design, which resulted in more valid and reliable findings. The inadequacies of an individual method were minimised and more threats to internal validity were realised and addressed (Fielding and Schreier, 2001).

3.7 SUMMARY

This chapter has outlined the methodology or procedures used to carry out this research study. Important aspects included the discussion of the type of research employed, research population and sample, research instruments and the discussion of internal validity. The next chapter will deal with the analysis of the research findings.

4 CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS OF DATA

4.1 INTRODUCTION

In this chapter the researcher reports on the findings of the imperical investigation conducted to investigate the use of information technology in learning and teaching secondary school mathematics in the three districts of Mafikeng, Zeerust and Lichtenburg in the North West Province of the Republic of South Africa.

The research findings were intended to address or provide solutions to the following research questions:

- Is Information technology an effective instructional tool to teach secondary school mathematics?
- What are the perceptions of learners and educators on the use of information technology in the learning and teaching of mathematics?
- What are the challenges faced by educators and learners when using information technology in the teaching and learning of mathematics?

4.1.1 PRESENTATION OF THE RESULTS

There were two sources where the data of the research findings was derived. These were: questionnaires of the educators and learners and the interviews of subject advisors. Research findings from both sources were presented in the form of tables, bar graphs and pie charts. A brief discussion accompanied each illustration given.

4.1.2 ANALYSIS OF DATA

4.1.2.1 INTRODUCTION

This section deals with how the data collected was analysed. All the data which was presented in the form of tables and was expressed as percentages. The higher the percentage implied the more prevalent that specific aspect was. In the case of pie charts, the magnitude of the angle showed prevalence of that specific item under discussion. Also, in the case of bar graphs the higher the bar implied the more prevalent of that specific aspect. In order to

analyse the data I also used the product moment coefficient (correctional analysis) to test the relationship between variables.

4.1.2.2 QUANTITATIVE AND QUALITATIVE ANALYSES

This research study combined both quantitative and qualitative analysis of data techniques.

A quantitative analysis involves the collection and analysis of data in numerical form. A researcher typically conducts a quantitative research analysis in order to:

- Test the existence of relationships between variables of interest, or
- Make inferences about the quantity of specific attributes in a population based on measurements derived from the sample.

The advantages of using quantitative analysis were that

- Broadly speaking quantitative is thought to be objective. It is believed that in gaining, analysing and interpreting quantitative data, the research remained detached and objective.
- It is deductive in that it tests theory.
- Quantitative analysis of research produces results that can be generalized to new situations.
- Quantitative analysis uses data that is structured in the form of numbers or that can immediately be transferred into numbers. Data from questionnaires in this study can easily be quantified. (Fielding and Schreier, 2001).

In both questionnaires the structure of the questions in section B were in the form of the Likert Scale. The reason for using the Likert Scale was that the results from the findings of the questionnaires could be quantified. Hence it was easy to apply the quantitative method of analysis.

In general, qualitative research analysis generates rich detailed and valid (process) data that contribute to an in-depth understanding of the context in which the phenomenon under study takes place. Quantitative analysis generates reliable population based and generalised data

and was well suited to establishing cause-and-effect relationships. Combining quantitative and qualitative data analysis in a research study is becoming more and more common (Caserbeer and Verhoef, 1997). The advantages of combining both types of research analysis include:

- Research development (one approach is used to inform the other).
- Increased validity (confirming of results by means of different data sources).
- Complementary (adding information, i.e. words to numbers and vice versa)
- Creating new lines of thinking, by the emergence of fresh perspectives or contradictions (Fielding and Schreier, 2001).

4.2 RESULTS AND ANALYSIS

4.2.1 DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

There were two types of respondents involved in the research study namely learners and educators.

4.2.1.1 DEMOGRAPHIC CHARACTERISTICS OF LEARNERS

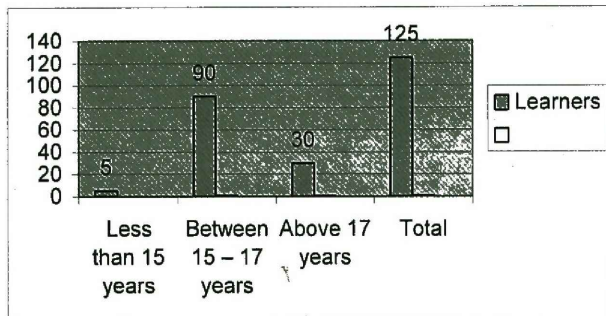
The sample for learners in this study was drawn from eight high schools in the Mafikeng, Zeerust and Lichtenburg Districts of the North West Province of the Republic of South Africa. A total of one hundred and twenty five learners successfully completed the designed questionnaires. The following table was constructed to give the general demographic characteristics of the learners who took part in the research study.

Table 1: Gender distribution of learners

Gender	Number of learners	Percentage
Male	53	43%
Female	72	57%
Total	125	100%

Table 1 illustrates that 53 male learners (43%) and 72 female learners (57%) took part in the research study. This shows that female learners were more than male learners. These results are consistent with the national demographics on gender distribution.

Figure 1: Age distribution of learners



From Figure 1, the analysis of the age of the respondents showed that 5 learners i.e. 4% were less than 15 years of age, 90 learners (72%) were between 15 years and 17 years of age and 30 learners (24%) were above 17 years of age. This shows that the majority of the learners who participated in the research study were between the ages of 15 and 17 years.

Table 2: Learner involvement in Mathematics and Computer Studies learning areas

		Number of Learners	Percentage
Mathematics is one of the learning areas of the learner	Yes	121	97%
	No	4	3%
	Total	125	100%
Computers is one of the learning areas of the learner	Yes	78	62%
	No	47	38%
	Total	125	100%

Table 2 shows that 121 learners (97%) had mathematics as a learning area, only 3 learners (3%) were not studying mathematics. It is also evident that 78 (62%) learners studying mathematics also studied computer studies. In other words 62% of the learners in research study who were taking mathematics had a strong base in information technology. In conclusion, one can say the majority of learners who participated studied both mathematics and computer studies.

The table also shows that the majority of learners who were learning mathematics had some exposure to information technology. In other words the majority of learners who took part in the research study knew what a computer was and what it was capable of.

Figure 2: Students with computers at home

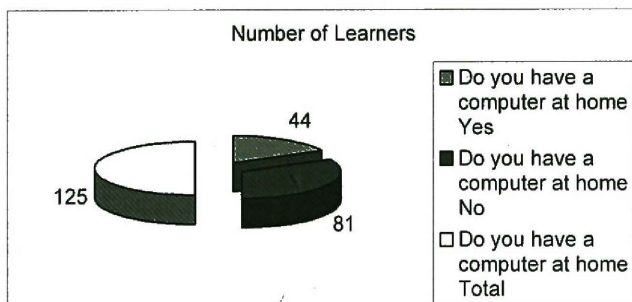


Figure 2 shows that out of a total number of 125 learners, 44 learners (35%) had computers at home and 81 learners (65%) did not have computers at home. This shows that the learners with computers at home were fewer than those who did not have computers at home. This implies that the majority of the learners learned computers at school. Any meaningful use of computers to learn mathematics had to take place at school.

4.2.1.2 DEMOGRAPHIC CHARACTERISTICS OF EDUCATORS

The sample for educators in this research study was drawn from eight high schools in the Mafikeng, Zeerust and Lichtenburg Districts of North West Province. A total of forty-one educators successfully completed the designed questionnaires. The following tables were constructed to give a summary of the demographic characteristics of the educators who took part in the research study.

Table 3: Gender distribution of educators

Gender	Number of educators	Percentage
Male	19	46%
Female	22	54%
Total	41	100%

From table 3, the analysis of the gender of educators shows that 19 educators (46%) were male and 22 educators were female (54%). Although the number of female respondents was slightly more than the male respondents, one is tempted to say there was a fair representation of both sexes in this research study.

Table 4: Professional qualification of educators

Qualification	No. of educators	Percentage
Secondary teacher's course	15	37%
University degree	11	26%
Diploma in education	15	37%
Total	41	100%

From Table 4 the analysis of the professional qualifications for educators shows that 15 educators (37%) had a Secondary Teacher's Course, an equal number of educators had Diplomas in Education, 11 educators (26%) had a University degree. From the table we can conclude that all the educators were adequately qualified to teach at high schools.

Table 5: Type of employment of educators

Position	Number of educators	Percentage
Head of Department	6	15%
Educator	31	76%
Relief educator	4	10%
Total	41	100%

Table 5 shows that 6 educators (15%) were Heads of Departments, 31 educators (76%) did not hold other positions of responsibility and 37 educators (90%) were full time educators.

Table 6: Age distribution of educators

Age (years)	Number of educators	Percentage
Between 20 – 29	10	24%
Between 30 – 39	18	44%
Between 40 – 49	8	20%
Between 50 – 59	5	12%
Total	41	100%

Table 6 shows that 18 educators (44%) were between 30 – 39 years, 10 educators (24%) were between 20 – 29, 8 educators (20%) were between 40 – 49 years and 5 educators (12%) were between 50 – 59 years old. The table shows that the majority of the educators, who took part in the research study, were quite young.

4.2.1.3 SUMMARY OF TABLE 4, TABLE 5 AND TABLE 6

Table 4 shows that all the educators who took part in this research sample were adequately qualified. Table 5 shows that all educators except four were employed on a full time basis. Table 6 shows that the majority of educators were quite young. The fact that educators are adequately qualified and are quite young should allow them to use information technology in the teaching and learning of mathematics. The latter is confirmed in Table 16 when the majority of the educators (76%) confirmed that computers could be used as effective instructional tool in the teaching and learning of mathematics. It can be concluded that the younger and more qualified the educators were the more likely they were to embrace new teaching strategies such as the use of information technology in the teaching of mathematics.

Table 7: Years of teaching experience of educators

Number of years	Number of educators	Percentage
0 – 5	10	24%
6 – 10	14	34%
11 – 15	5	12%
16 – 20	6	15%
20+	6	15%
Total	41	100%

An analysis of the years of teaching experience of the educators indicates that 14 educators (34%) had between 6 and 10 years of experience. 10 educators (24%) had teaching experience of between 0 – 5 years, 5 educators (12%) had between 11 – 15 years of teaching experience, and the 16 – 20 and the more than 20 years categories each had 6 educators (15%). From Table 6 one can conclude that the majority of the educators who took part in the research study had between 6 – 10 years of teaching experience.

Table 8: Terms of service of educators

Terms of service	Number of educators	Percentage
Permanent	25	60%
Temporary	8	20%
Contract	8	20%
Total	41	100%

Table 8 illustrates that twenty-five of the educators (60%) were employed on a permanent basis. The categories of Temporary and Contract each contributed eight educators (20%). However, from the table we can conclude that the majority from the sample of educators were employed on a long-term basis.

Table 9: Subjects taught by educators.

Subject	Number of educators	Percentage
Mathematics	27	66%
Computer Studies	10	24%
Mathematics and Computer Studies	4	10%
Total	41	100%

From Table 9 twenty educators (66%) were mathematics educators, ten (24%) were computer studies educators and four (10%) were teaching both mathematics and computer studies. From the table of results one can conclude that the majority of the educators who took part in the research sample were mathematics educators. The results also show that only four educators were teaching both computer studies and mathematics. This emphasises the importance of providing workshops and seminars on the use of computers to mathematics educators (Table 18).

Table 10: Number of computers in schools

Number of computers	Number of educators	Percentage
11 – 15	7	17%
16 – 20	9	22%
20 ⁺	25	61%
Total	41	100%

Table 10 shows the distribution of computers in the schools whose educators took part in this research study. Sixty one percent of the schools had more than twenty computers. Twenty

two percent had between sixteen and twenty computers and seventeen percent had between eleven and fifteen computers. All schools that took part in this research study had computers. Although all the schools that took part in this study had computers, the distribution of the number of computers per school did not seem to be adequate. Only 61% of the educators had a reasonable number of computers at their schools. According to 39% of the educators the number of computers was barely enough. The information in the table above does confirm one of the challenges that there is a shortage of hardware and software in schools (Table 18) faced by educators as they adopted a curriculum where computers play a pivotal role in the teaching and learning of mathematics.

4.3 LEARNERS' PERCEPTION ON THE USE OF INFORMATION TECHNOLOGY

The following section deals with the perceptions of learners on the use of Information technology as an instructional tool. The results analysis can be summarized in three distinct sections, which are:

- The role of teaching aids in the learning of mathematics.
- How computers can help the learning of mathematics.
- Problems faced by learners on the use of computers.

Table 11: The role of teaching aids in the learning of Mathematics.

Statement	SD		D		UN		A		SA	
	No. of Learners	%	No. of Learners	%	No. of Learners	%	No. of Learners	%	No. of Learners	%
1. Mathematics can be understood much better when it is taught with teaching aids	1	1	14	11	12	10	40	32	58	46

Key: SD Strongly disagree
D Disagree
UN Undecided
A Agree
SA Strongly Agree

Table 11 summarises the perception of learners on the role of teaching aids in the learning of mathematics. From the table, ninety-eight learners (78%) agreed that mathematics can be

understood much better when it is taught with teaching aids, twelve learners i.e. 10% where undecided and fifteen (12%) disagreed.

The table shows that the majority of the learners agreed in principle that mathematics can be understood better when instructional tools were used. If the results from table 12 are compared with the results from table 12, it can be noted that the learners rated the computer highly as a useful teaching aid. The majority of the learners believed that computers can be used to carry out mathematical calculations, sketching graphs using computers was an interesting experience and that mathematics educators should use computers to explain mathematical concepts. Table 11 and table 12 emphasized the importance of teaching aids and the importance of information technology as an effective instructional tool.

Table 12: Computers and the learning of Mathematics

Statement	SD		D		UN		A		SA	
	No. of Learners	%	No. of Learners	%	No. of Learners	%	No. of Learners	%	No. of Learners	%
1. Computers can be used to carry out mathematical calculations	1	1	3	2	18	14	70	56	33	26
2. Using computers to sketch graphs is an interesting experience	3	2	4	3	16	13	59	47	43	34
3. Mathematics educators use computers to explain mathematical concepts	9	7	18	14	29	23	38	30	31	25

Key: SD Strongly disagree
D Disagree
UN Undecided
A Agree
SA Strongly

From Table 12 it shows that one hundred and three learners (82%) agreed with the fact that computers can carry out mathematical calculations, eighteen learners (14%) were undecided on the latter role of computers.

The table also shows that one hundred and two learners (82%) agreed that the use of computers to sketch graphs was an interesting experience, sixteen learners (13%) were undecided and seven learners (6%) disagreed. This information confirmed learners regard information technology as an effective instructional tool in the teaching and learning of mathematics.

Table 13: Challenges faced by learners on the use of computers to learn Mathematics: Learners' Perception.

Statement	SD		D		UN		A		SA	
	No. of Learners	%	No. of Learners	%	No. of Learners	%	No. of Learners	%	No. of Learners	%
1. Learners find computers difficult to use because they do not have computers at home and are not given enough time to use them at school.	5	4	-	-	5	4	48	38	67	54
2. Schools do not have enough computers for learners to practice their mathematics	4	3	13	10	23	18	41	33	44	35

Key:
SD Strongly disagree
D Disagree
UN Undecided
A Agree
SA Strongly Agree

Table 13 shows that, one hundred and fifteen learners (92%) said that they found computers difficult to use because they did not have computers at home and that their respective schools did not give them enough time to use computers, five learners (4%) were not decided and five learners (4%) disagreed on the same issue. This latter confirmed one of the challenges faced by learners as they endeavour to use computers to learn mathematics.

On the aspect of whether schools had enough computers for learners to practise mathematical concepts, eighty-five learners (68%) agreed, that they did not, twenty-three (18%) were

undecided and twenty learners (14%) disagreed. Ninety-eight learners (78%) indicated that mathematics educators should show learners how to use the computer to carry out mathematical concepts, sixteen learners (13%) were not decided and eleven learners (9%) disagreed on the same aspect. The table shows that one hundred and nine learners (87%) agreed that computer studies lessons should show them how to do mathematics on the computer, twelve learners (10%) were undecided and four learners disagreed on the same aspect.

A summary of table 13 shows that:

- Learners found computers difficult to use, learners did not have computers at home and schools did not give learners enough time to use computers.
- Schools did not have enough computers for learners to use. The numbers of computers per school were barely enough to be used by the whole school.
- Educators should be empowered to show learners how to use computers to learn mathematics. Quite a number of educators did not know how to use appropriate software to teach mathematics. This was a huge challenge.

4.4 EDUCATORS' PERCEPTIONS ON THE USE OF INFORMATION TECHNOLOGY TO TEACH MATHEMATICS

The following section provides a summary on the perceptions of educators on the use of Information technology in the teaching and learning of mathematics. This section will examine the following aspects:

- The role of information technology in the teaching and learning of mathematics.
- Challenges faced by educators on the use of computers to teach mathematics.

Table 14: The role of information technology in the teaching and learning of Mathematics: Educators' Perception

Statement	SD		D		UN		A		SA	
	No. of Educators	%	No. of Educators	%	No. of Educators	%	No. of Educators	%	No. of Educators	%
1. Instructional tools are important in the teaching and learning of mathematics at high school level	-	-	-	-	-	-	22	54	19	46
2. Information technology can be used as an effective instructional tool in the teaching and learning of mathematics	-	-	4	10	6	15	17	43	14	34
3. Computer lessons should teach learners how to use computers to perform mathematical calculations and to draw graphs.	4	10	-	-	3	7	19	46	15	37

Key: SD Strongly disagree
D Disagree
UN Undecided
A Agree
SA Strongly Agree

Table 14 shows that 41 educators (100%) agreed that instructional tools are important in the teaching and learning of mathematics at high school level. Thirty-one educators (76%) agreed that information technology (computers) can be used as an effective instructional tool in the teaching and learning of mathematics, six educators (15%) were undecided and only four educators (10%) disagreed with that role of computers.

From table 14, it is also clear that thirty four educators (83%) agreed that computer studies should teach learners how to use computers to perform mathematical calculations and to draw graphs, three educators (7%) were undecided and four educators (10%) disagreed on this aspect. A summary of table 16 indicates that computers can be used as an effective instructional tool and that a majority of educators believed that learners should be shown how to do mathematical calculations in computer lessons.

Table 15: The use of computer-based activities in the teaching of mathematics: Educator's Perception.

Computer-based activity	Number of Educators using the computer-based activity	%
Graphs and diagrams	32	75
Calculations	32	75
Computer simulations	16	39
Spreadsheet analysis issues	35	85
Internet search for science information	20	49
Drill and practice	15	36
Test and assignment	6	15
Software programmes	16	39

Table 15 shows that the majority of educators (above 75%) used computers to do graphs and diagrams and calculations. The use of spreadsheets was also very popular with the educators (85%). Half the educators also indicated that they used the Internet to search for science information. Computer-based activities such as the use of computer simulations, drill and

practice and software programmes were used by 39%, 36% and 39% of the educators respectively. The latter results showed that quite a number of educators were not comfortable in using software programmes and compute simulations when teaching mathematics. Table 18 also confirmed the notion that educators were not trained enough to use software packages. The least used computer-based activity concerns “test and assignment” with only six educators (15%) using it. The reason might be that there is no appropriate software for educators to use when it comes to “test and assignments” activities.

In summary, Table 15 shows that the decision to use information technology to teach mathematics rested with the educators. However, the multi-million dollar question is: Why were mathematics educators not embracing the winds of change and starting to use information technology in the learning and teaching of high school mathematics? According to the research study, there are challenges faced by educators as they endeavour to integrate information in the teaching and learning of mathematics. Some of the challenges are due to lack of training on the part of educators and some challenges go beyond the physical boundaries of the classrooms.

In summary, the two most important reasons that indicated why educators do not use information technology were that educators were not trained to use information technology as an instructional tool and that the education department was not doing enough in providing comprehensive in-service programmes to train educators on how to use computers as an instructional tool. Until a stage is reached where the educators can effectively use information technology, the fruits of the instructional tool will not be realised by the intended beneficiaries, that is, the learners.

Table 16: Challenges faced by educators on the use of Information technology in the teaching of Mathematics: Educators' Perception

Challenges	SD		D		UN		A		SA	
	No. of Educators	%	No. of Educators	%	No. of Educators	%	No. of Educators	%	No. of Educators	%
Educators have not been trained to use computers	4	10	7	17	-	-	20	49	10	24
Educators are not empowered to make the decision to use computers	3	7	8	20	9	22	15	36	6	15
Educators feel the use of computers is part of the learning in computer studies	-	-	6	15	8	20	20	49	7	16
Headmasters choose not to buy computers	12	29	16	39	7	17	3	7	3	7
There is no money to buy computers	3	7	8	20	7	17	6	15	17	41
There are no technicians on site to maintain the computers	4	10	9	22	6	15	10	24	12	29
Schools do not have the infrastructure to accommodate the computers	6	15	22	54	4	10	5	12	4	10
The department should organise workshops on the computer as an instructional tool.	-	-	6	15	3	7	16	39	16	39

Key:

SD	Strongly disagree
D	disagree
UN	Undecided
A	Agree
SA	Strongly Agree

Analysis of table 16 shows that thirty educators (73%) believed that educators had not been trained to use computers to teach mathematics and eleven educators (27%) disagreed. Twenty-one educators (50%) said educators were not empowered to make the decision to use computers, nine educators were undecided and eleven educators (27%) disagreed. The table also shows that twenty-seven educators (65%) felt that the use of computers was part of the lessons in computers studies, six educators (15%) disagreed and eight (20%) were undecided. Twenty-eight (68%) educators disagreed with the idea that headmasters choose not to buy computers, six educators (16%) agreed with the statement and seven (17%) were undecided.

In as far as infrastructure to accommodate the computers in schools is concerned, twenty-eight educators (69%) disagreed with the fact that schools did not have the infrastructure to accommodate computers, four (10%) were undecided and nine (16%) agreed. Thirty-two educators (78%) agreed that the education department should organise workshops on the computer as an instructional tool, three (7%) were undecided and six (15%) disagreed. Twenty-two (51%) educators indicated that there were no computer technicians on site to maintain the computers, six (15%) were not decided and eleven (32%) educators disagreed.

In summary Table 16 shows that:

- Educators were not trained and empowered to use computers to teach mathematics. The demographics of educators showed that the majority of the educators who participated in this research sample were qualified professionals who were quite young. This shows that the educators were not ignorant about the role information technology can play in everyday life. What these educators were not probably aware of, to a greater detail, was the role information technology can play in the teaching and learning of mathematics. In order to make aware the role of information technology in the teaching and learning of mathematics to educators, the education department should organise workshops, seminars and conferences to train and in-service educators on the use of information technology as an instructional tool in the teaching of mathematics.
- Educators felt that the use of computers was part of computer studies. Quite a number of educators, due to ignorance, felt that the need for integrating information technology into the teaching and learning of mathematics was utter rubbish. The educators argued that most of the applications of information technology were done

in computer studies, which is not very true. This factor just boils down to the fact that educators were not trained to use information technology as an instructional tool.

- Headmasters did not choose not to buy computers. In fact there was no money to buy and maintain computers. Although the schools that took part in the study had computers, the numbers were barely enough to meet the demands.

Interviews of subject advisors suggested that the majority of the schools were poorly funded and regarded the buying and installation of computers as a luxury. Whilst it was true that the government should fund educational programmes in public schools, the government should not be the sole sponsor of education programmes in these public schools. The school Governing Bodies can help in funding viable educational programmes, for example, providing computers for the learning and teaching of mathematics. In South Africa there is also provision for external donors to fund educational programmes. These donors include USAID programmes and individuals like Mark Shattleworth also sponsor science programmes in schools. In a nutshell one can say that where there is a will there is a way, headmasters and the education department should seek ways to fund educational programmes. There was also another argument that even if the computers were bought, schools did not have the technicians on sight to maintain them. Trained technicians would rather work in industry and commerce where they were better paid. Sponsorship should also be sought for the retention of technicians.

- Schools had the infrastructure to accommodate computers. In terms of infrastructure to accommodate the computers, educators believed that there were enough infrastructures in almost all schools. In some schools not all classrooms were used.

4.5 RELATIONSHIP BETWEEN THE VIEWS OF EDUCATORS AND LEARNERS ON THE USE OF COMPUTERS

The variables in this research refer to perceptions of both educators and learners on the use of information technology in the learning and teaching of mathematics. These perceptions include, whether information technology is an effective instructional tool and whether mathematics can be understood better with the use of a teaching aid.

In order to test the relationships between two variables, the researcher used correlational analysis. Correlational analysis involves comparing data in order to determine whether and to what extent, a relationship exists between two quantified variables. The degree of relationship is expressed as a correlation coefficient, which is based on the two sets of scores. This correlation coefficient provides an estimate of just how related two variables are. If two variables are highly related, a correlation coefficient near +1.00 or -1.00 will be obtained, if two variables are not related, a coefficient near 0.00 will be obtained. There are a number of different methods of computing a correlation coefficient which are appropriate depending upon the scale of measurement represented by the data. In this research study, the product moment coefficient, usually referred to as Pearson, r , was used (Crashaw and Chambers, 1990).

The following relationship was analysed, based on the data gathered. From the learners and educators' questionnaires:

- Is there a relationship between the number of educators who said instructional tools were important in the learning and teaching of mathematics and the number of educators who thought Information technology was an effective instructional tool in the teaching of mathematics?

4.5.1 INFORMATION TECHNOLOGY AS AN EFFECTIVE INSTRUCTIONAL TOOL

QUESTION: Is there a relationship between the number of educators who said instructional tools were important and the number of educators who believed that information technology was an effective instructional tool in the teaching and learning of mathematics?

From Table 16 the following information is obtained.

	SD	D	UN	A	SA
Instructional tools are important (X)	0	0	0	22	19
Information technology is an effective instructional tool (Y)	0	4	6	17	14

Applying the product moment correlation coefficient, Pearson, r , the following computations were obtained:

X	Y	X ²	Y ²	XY
0	0	0	0	0
0	4	0	16	0
0	6	0	36	0
22	17	484	189	374
19	14	361	196	266
$\Sigma X = 41$	$\Sigma Y = 41$	$\Sigma X^2 = 845$	$\Sigma Y^2 = 640$	$\Sigma XY = 640$

$$\begin{aligned}
 r &= \frac{640 - \frac{(41)(41)}{5}}{\sqrt{(845 - 336.2)(537 - 336.2)}} \\
 &= \frac{640 - 336.2}{\sqrt{(508.8)(200.8)}} \\
 &= \frac{303.8}{\sqrt{10167.04}} \\
 &= \frac{303.8}{319.6} \\
 &= 0.951
 \end{aligned}$$

INFERENCE

The variables X and Y have a correlation coefficient near +1.00. This means that there was a strong correlation between the number of educators who said instructional tools were important and the number of educators who believed that information technology was an effective instructional tool in the teaching and learning of mathematics in high schools.

4.6 SUMMARY OF RESULTS

This section provides a summary of data collected in this research study. The majority of educators (77%) and all subject advisors agreed information technology was a powerful and effective instructional tool which encouraged collaborative learning, thus helping learners realise their full potential when learning mathematics. Learners (82%) agreed that Information technology makes calculations and sketching of graphs interesting. The research has also shown that there were a number of challenges faced by educators and learners in using information technology in the teaching and learning of mathematics. These challenges included: lack of training on the part of educators on how to use information technology and lack of funds to buy hardware and software.

5 CHAPTER FIVE: SUMMARY AND CONCLUSION

5.1 INTRODUCTION

This final chapter of the research study deals with the following subsections:

- **Reflections** – will consist of a brief summary of each of the research questions being investigated, the procedures employed and the results obtained.
- **Conclusions** – will consist of the implications of the findings, their meaning and significance.
- **Recommendations** – will refer to suggestions for further research.

5.2 REFLECTIONS

The research findings were intended to provide solutions or answers to the following research questions:

- Is information technology an effective instructional tool to teach secondary school mathematics?
- What are the perceptions of learners and educators on the use of information technology in the teaching and learning of mathematics?
- What are the challenges faced by educators and learners when information technology is used in the learning and teaching of mathematics?

RESEARCH QUESTION: IS INFORMATION TECHNOLOGY AN EFFECTIVE INSTRUCTIONAL TOOL TO TEACH SECONDARY SCHOOL MATHEMATICS?

This research question sought to find out if information technology was an effective instructional tool in the teaching and learning of secondary school mathematics.

The data for this research question was obtained from responses of educators' and learners' questionnaires. Form the research findings the following were concluded:

- Table 14 indicates that the majority of educators (76%) agreed that computers were an effective instructional tool in the teaching of mathematics.

- Table 12 indicates that learners (81%) agreed that computers can be used to carry out mathematical calculations and can make sketching of graphs interesting.
- A strong correlation coefficient of 0.951 was obtained between the number of educators who said instructional tools were important and the number of educators who believed that information technology was an effective instructional tool in the teaching and learning of mathematics in high schools.

The findings on the research question are consistent with Johnson's research (1994), which concluded that computers aided concentration by focusing the learners' attention on the work at hand. According to Johnson (1994), as the result of the use of computers some learners and educators believed that the standard of work produced was of a higher quality than it would have been otherwise. Paul (1998) and Hawkridge (1990) identified and described the pedagogic rationale for the use of computers in South African schools. This rationale is based on the belief that computers were able to teach and that computer aided learning and computer aided instruction offered certain advantages over traditional methods. Kulik (1994) in Sewell and Burger (1999) acknowledged that students usually learn more in classes in which they received computer-aided instruction. In the North West Province of South Africa, there is no previous research on the computer as an effective instructional tool. It is quite possible that this is one of the first few studies in the province on computers as an instructional tool in schools.

In conclusion, there was overwhelming evidence that educators and learners regard information technology as an effective instructional tool in the teaching and learning of mathematics.

RESEARCH QUESTION: WHAT ARE THE PERCEPTIONS OF LEARNERS AND EDUCATORS ON THE USE OF INFORMATION TECHNOLOGY IN THE TEACHING AND LEARNING OF MATHEMATICS?

This research question sought to find out the perceptions of learners and educators on the use of information technology in the teaching and learning of mathematics. Data pertaining to

this research question was obtained from the responses from both learners' and educators' questionnaires. The following research findings were obtained:

- From table 15, educators agreed that:
 - Computer-based activities such as graphs and diagrams (75% of educators), calculations (75% of educators) and spreadsheet analysis issues (85% of educators) were the activities commonly used by the educators during mathematics lessons

RESEARCH QUESTION: WHAT ARE THE CHALLENGES FACED BY EDUCATORS AND LEARNERS WHEN INFORMATION TECHNOLOGY IS USED IN THE LEARNING AND TEACHING OF MATHEMATICS?

This research question sought to find the challenges faced by both educators and learners as they used information technology to teach and to learn mathematics.

In order to find the relevant data to this research question the researcher used questionnaires for educators and learners. The analysis of the questionnaires showed the following challenges to be prevalent:

- Learners found computers difficult to use, learners did not have computers at home and schools did not give learners enough time to use computers.
- Educators and learners felt that the use of computers had more to do with computer studies, and according to educators and learners, all computer work was to be done in the computer department.
- Schools did not have enough computers, there was no money to buy and maintain the computers.
- Educators were not trained and empowered to use computers to teach mathematics.
- The Department of Education in conjunction with subject advisors should organise more workshops, seminars and conferences on the use of computers as an instructional tool in the teaching and learning of mathematics.
- The perception on the use of computers in the teaching of Mathematics in general has to be changed.

Johnson (1994) acknowledges that failures to detect the contributions through the use of information technology may be attributed to the problems encountered by learners and

educators such as difficulties in using a particular software package. The latter collaborates the research findings of this study in that educators felt that they were not well trained to use Information technology to teach mathematics. The research study confirmed the reasons why computers were not used for learning and teaching in schools in East London in South Africa, that is according to Paul (1998).

According to Paul:

- The majority of the educators felt inadequately prepared to use technology resources particularly computer based technologies.
- There is generally a shortage of computers in great numbers to provide access for educators and learners due to prohibitive high costs of hardware and software.

As part of the solution to the latter problems, the education department should provide effective professional development to educators in the form of workshops and seminars. More thought need to be given to designing a curriculum. Educators and other stakeholders should have patience, change will not occur overnight.

5.3 IMPLICATIONS OF THE RESEARCH FINDINGS

This research study on views of educators and learners regarding the use of information technology as an instructional tool in the teaching and learning of secondary school mathematics has unveiled great curricular implications. These implications are:

- The approach, which the computer requires, is essentially one which encourages pupils to play an active part in their own learning. Access to computers encourages the less traditional styles of learning and teaching mathematics, such as problem solving, investigation, discussion and extended work.
- The use of the computer creates a new environment, where the task of the teacher changes from a giver of information to the facilitator who can guide pupils towards approaches, which deal with the problem under consideration and who, most importantly, can establish through discussion the links with related concepts and topics, which are essential for sound mathematical development. This represents a significant departure from a teacher as one who, from a position of authority, passes knowledge to pupils and directs their work in considerable detail.

- From the research study, educators and learners regard information technology as an effective instructional tool. By using information technology, learners can learn existing curricular content, skills and concepts more readily, more enjoyably, with better understanding and with an enhanced ability to apply the mathematical concepts.

5.4 MEANING AND SIGNIFICANCE OF THE RESEARCH FINDINGS

The use of appropriate information technology in the teaching of mathematics is an integral part of the Outcomes Based Education system, which the South African government has adopted. The findings of this research study support the use of appropriate technology in the teaching and learning of mathematics in high schools in South Africa. Research findings have also highlighted the challenges associated with the use of information technology in the teaching and learning of mathematics in the high schools. An analysis of these challenges will provide all the stakeholders in the education departments an insight into these challenges as they endeavour to implement a technology-integrated curriculum. The National Department of Education, Provincial Departments and Universities can also take a leaf from this research study, and provide in-service courses for educators on the use of information technology in the teaching and learning of mathematics in high schools. The Outcomes Based Education curriculum includes several helpful references on the use of computers to teach and learn mathematics. This study provides practical suggestions on implementation considerations of Outcomes Based Education. However, because this is not part of written testing, many secondary mathematics departments still manage to avoid using information technology at all. They use an argument, for example, that database work is done within the technology curriculum anyway. The latter is a great challenge to all stakeholders because it represents the need for a change of attitudes towards the use of computers in the teaching and learning of mathematics at high school level.

5.5 CONCLUSIONS

The research study has dealt with issues concerning the use of information technology in the teaching and learning of mathematics. In summary, the research has concluded that:

- Educators and learners regard information technology is an effective instructional tool in the teaching and learning of mathematics.

- Challenges in the use of information technology included, lack of hardware, software, and educators not trained to use computers, and that learners find computers difficult to use.

5.6 RECOMMENDATIONS

The research findings of this research study have shown that educators regard information technology as an effective instructional tool. The major challenges hampering the use of information technology in the teaching and learning of mathematics are lack of hardware and software and the fact that educators are not trained to use information technology in their lessons.

Based on these research findings I recommend the following:

- The Education Department in conjunction with the Faculty of Education of the North West University set up comprehensive in-service training programme for mathematics educators in the North West Province. These in-service training programmes can take the form of workshops, seminars and conferences. The main aim of these programmes will be to educate and train educators on the use of information technology in the teaching and learning of mathematics.
- There should be a deliberate attempt to provide the hardware and software necessary for the implementation of information technology in the teaching and learning of mathematics. The donor community can also play a pivotal role in the latter.
- The use of information technology to teach mathematics should be part of the Teacher Education training curriculum at the North West University.
- The Education Department in conjunction with the Faculty of Education at the North West University should provide written materials and manuals on how information technology can be used in the learning and teaching of mathematics in the North West Province.

5.7 FURTHER RESEARCH

The proposed research areas for further research are the following:

- Is there any correlation between the grades of learners and the use of Information technology (i.e. can the use of computers actually improve the grades of learners). This study will require a comparative study of the grades of two groups, one using information technology as an instructional tool in the learning of mathematics and the other group not using information technology.
- The role of the government (Education department) in the integration of information technology in the teaching and learning of mathematics in high schools: challenges.
- The development and evaluation of software for teaching and learning mathematics at high school level. One of the problems which educators and learners find, when they use information technology to teach and learn mathematics, is the lack of appropriate software. This research will be aimed at the development and evaluation of new appropriate software in the teaching and learning of mathematics.
- Investigating computer-supported collaborative learning from an affective perspective.

5.8 SUMMARY

The role that information technology can play in enhancing the quality of teaching and learning of mathematics in the classrooms in the North West Province and in South Africa in general cannot be overemphasised. This research has highlighted the immense potential provided by information technology in the teaching and learning of mathematics in high schools. The research findings show that educators and learners regard information technology as an effective instructional tool to learn mathematics. This research study has also highlighted the challenges faced by both educators and learners as they endeavour to use information technology in the teaching and learning of mathematics. These challenges include lack of funds to buy hardware and software and lack of in-service training programmes for educators on the use of information technology to teach mathematics. The research findings of this research study can be supported by further research on the development and evaluation of relevant software for the teaching and learning of high school mathematics.

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APPENDICES

APPENDIX I QUESTIONNAIRE FOR LEARNERS

**TITLE: THE USE OF INFORMATION TECHNOLOGY AS AN INSTRUCTIONAL TOOL IN
THE LEARNING OF SECONDARY SCHOOL MATHEMATICS**

INSTRUCTION TO LEARNERS

Please complete Section A and Section B

SECTION A

You are kindly requested to complete this section of the questionnaire by ticking (✓) in the appropriate box provided at the end of the statement.

1. Type of school

Middle	
High	

2. Gender

Male	
Female	

3. Your age

Less than 15	
15 – 17	
17 ⁺	

4. Is mathematics one of your learning areas?

Yes	
No	

5. Is computer study one of your learning areas?

Yes	
No	

6. Do you have a computer at home?

Yes	
No	

SECTION B

Items 1-10 are statements on various aspects on the use of information technology (computers) as an instructional tool in the teaching of mathematics in your school and district.

Each statement is responded by ticking (✓) in the relevant box. Boxes are under columns labelled: Strongly Agree, Disagree, undecided, agree and strongly disagree.

STATEMENT	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
1. Mathematics can be understood much better when it is taught without teaching aids (objects to illustrate ideas)					
2. Mathematics can be understood much better when it is taught with teaching aids (objects to illustrate ideas)					
3. Computers can be used to carry out certain mathematical calculations, such as averages.					
4. Using computers to sketch various graphs is an interesting experience.					
5. Mathematics educators at my school should use computers to explain mathematical ideas; this would enhance our understanding of the subject.					
6. Computer lessons at my school should show learners how to do some mathematical calculations and graphs on computers.					
7. Many learners find computers difficult to use because they do not have computers at home and are not given enough time to use computers at school.					
8. My school does not have enough computers for students to practice their mathematical ideas and calculations on.					
9. Our mathematics educators need to show us how to use the computers to carry out mathematical calculations and illustrations.					

APPENDIX II QUESTIONNAIRE FOR EDUCATORS

TITLE: *THE USE OF INFORMATION TECHNOLOGY AS AN INSTRUCTIONAL TOOL IN THE TEACHING OF SECONDARY SCHOOL MATHEMATICS*

INSTRUCTIONS TO EDUCATORS

Please complete Section A, Section B and Section C.

SECTION A: PERSONAL DETAILS

You are kindly requested to complete this section of the questionnaire by ticking (✓) in the appropriate box provided at the end of the statement.

7. Type of school

Middle	
High	

8. Gender

Male	
Female	

9. (a) Academic Qualification

Below Metric	
Metric	
Junior Degree	
Honours Degree	
Masters Degree	
Other (Specify)	

(b) Professional Qualification

Primary Teachers' Course	
Secondary Teachers' Course	
University Degree	
Diploma	
Other (Specify)	

10. What is your position in the school?

Head of Department	
Educator	
Relief Educator	

11. Your age

Below 20	
Between 20 – 29	
Between 30 – 39	
Between 40 – 49	
Between 50 – 59	
60 ⁺	

12. Years of teaching experience

0 – 5	
6 – 10	
11 – 15	
15 – 20	
20 ⁺	

13. Terms of service

Permanent	
Temporary	
Contract	

14. Subject taught

Mathematics	
Computers	

15. Number of computers in your school

0 – 5	
6 – 10	
11 – 15	
16 – 20	
20 ⁺	

SECTION B

Items 11-23 are statements on various aspects on the use of information technology (computers) as an instructional tool in the teaching of mathematics in your school and district.

Each statement is responded by ticking (✓) in the relevant box. Boxes are under columns labelled: Strongly Agree, Disagree, undecided, agree and strongly disagree.

<u>STATEMENT</u>	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
10. Instructional tools are important in the teaching and learning of mathematics at high school level.					
11. Information technology (computers) can be used as effective instructional tools in the teaching and learning of mathematics.					
12. Educators at your school use Information technology (computers) to explain mathematics concepts.					
13. I use information technology (computers) to teach mathematics because it enhances the learner's performance.					
14. Information technology (computer) lessons should teach learners how to use computers to perform mathematical calculations and to draw graphs.					
15. There is enough software, which can be used to teach mathematics.					
16. Educators do not use information technology because their knowledge of computers is limited.					
(a) Educators have not been trained to use computers.					
(b) Educators are not empowered to make the decision to use computers.					
(c) Educators feel the use of computers is part of the lessons in information technology.					

17. Schools do not have enough computers for learners to practice their mathematical concepts and skills because:					
(a) The headmasters choose not to buy computers.					
(b) There is no money to buy computers.					
(c) There are no technicians on site to maintain the computers.					
(d) The schools do not have infrastructure to accommodate the computers.					
(e) Computers are not on demand, educators do not know how to use them.					
18. More workshops on how to use information technology as an instructional tool should be organised by the Education Department.					

SECTION C

This section is intended to find out what computer-based activities you use when teaching your students.

Please kindly indicate by ticking (√) in the table below which type of computer-based activities you are using in the process of teaching mathematics in your school.

Computer-based activity	Whether used or not	
	Yes	No
Graphs and diagrams		
Calculations		
Computer simulation		
Spreadsheet analysis of issues		

Graphics		
Internet search for science information		
Drill and practice		
Database		
Test and assignments		
Software programme		