AN INVESTIGATION OF THE USE OF COMPUTERS IN THE TEACHING AND LEARNING OF HYPERBOLIC GRAPHS IN GRADES 10 TO 12 MATHEMATICS

by

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Abstract

In this investigation an attempt was made to determine how learners and teachers use computers in the teaching and learning of hyperbolic graphs in Mathematics. A comprehensive literature study showed that there are many benefits in using computers to study Mathematics. The investigation was done in two phases. In the first phase, a questionnaire was given to learners. The second phase involved interviewing learners and teachers. Findings indicate that learners and teachers enjoy using computers in the teaching and learning of Mathematics. Analysis of the results shows that the use of computers in teaching and learning of Mathematics, in particular the teaching and learning of hyperbolic graphs is beneficial.

Key words: Computer, graph, Hyperbola, Mathematics, technology
DECLARATION

Student number: 3153804-5

I declare that “An investigation of the use of computers in the teaching and Learning of hyperbolic graphs in Grades 10 to 12 Mathematics” is my own work, and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

...........................................................................................................  .................................................................

Signature       Date
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I want to express my sincere gratitude to:

- My father, God the Almighty, for the ability and wisdom He gave me to complete the research;
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- Prof David Mogari, my supervisor, for his guidance and assistance throughout the duration of the study; and
- My wonderful husband Dr Simon and our lovely children, Hope, Lutendo and Blessing who supported me
DEDICATION

I want to dedicate this research study to the following people:
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- My family for their understanding when I spent much of my time on the computer;
- My late father Andries Tshikovhele Raungedzani Makhavhu, who taught me never to give up in education;
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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Plotting a graph requires one to first draw the calibrated system of axes and then mark out the points where on the graph will run. The procedure of plotting a hyperbolic graph tends to be challenging for learners because it has two foci, two asymptotes and two branches. All these have to be first determined before the graph can be plotted.

I note with concern that the way learners go about plotting the hyperbolic graphs tends to be laborious and time-consuming. Learners performed repeated algorithmic computations and determined the points and then plotted the graph. Gebrekal (2006) posits that the construction of graphs using paper and pencil has not only hindered learners’ progress in understanding graphs, but also fostered in them negative attitudes towards Mathematics in general and graphs in particular. A hyperbolic graph is defined by Waski (2012) as a plane curve having two branches.

Learners generally find Mathematics, as a subject, difficult to learn (Centre for Development and Enterprise (CDE), 2004). One possible reason for the difficulty is the way Mathematics is taught. According to Tarmizi, Ayub, Bakar and Yunus (2010), teachers teach Mathematics through the traditional paper and pencil approach. The paper and pencil approach is the manual procedure used to plot graphs in Mathematics (Waits, 1997), and, as noted above, it poses difficulties to learners. This contributes to the difficulties learners have with Mathematics.

Learners need Mathematics as it is a key subject for admission, particularly in areas such as engineering and medicine. Some of the learners even have a negative attitude
towards Mathematics because of the way it is taught (Mogari, Kriek, Stols & Ogbonnaya, 2009). However, there is an increasing realisation that computers may help secondary school learners to learn Mathematics and, thus, improve the teaching and learning of Mathematics.

According to Dunham and Dick (1994), graphing technologies have the potential to affect the teaching and learning of Mathematics, particularly in the area of graphs. Some authors recommend the use of technology at all levels of Mathematics instruction (Mehmet, 2002; Yushau & Wessels, 2003; Goos & Bennison, 2007; Naatanen, 2005; Alper, 2009). There are researchers who have been striving for better methods to teach Mathematics by, integrating new technological methods (e.g. Taylor, 1980; Fey, 1989; Dessart, DeRidder & Ellington, 1999; De Villiers, 1999; NCTM, 2000; Battista, 2001; Hannafin & Scott, 2001; Hennessy, Fung & Scanlon, 2001; Liu & Cummings, 2001; Tooke, 2001; Wiest, 2001; Ibrahim, 2004; Berger, 2010).

Several researchers have placed great emphasis upon learners’ thinking, active learning, discovery learning, and interest in Mathematics (e.g. Heid, 1989; Schroeder & Lester, 1989; Andrew, 1995; Ahuja, Lim-Teo & Lee, 1998; Choike, 2000). Ahuja and Jahangiri (2003) allude to the fact that the learner-centred Mathematics classrooms are now considered more effective than teacher-centred traditional classrooms. According to Raines and Clark (2011), research findings suggest that when learners are actively involved in the learning process, there is an increase in learning and persistence, higher grades and more thorough questioning.

There are studies (e.g. Ng & Gunstone, 2002; Dunham & Dick, 1994; Pomerantz, 1997; Rowlett, 2013) that have found that computers motivate learners to learn Mathematics. Difficult Mathematical problems can be solved by pressing a few keystrokes using a computer. Computers are important in that they can help deal with much more sophisticated mathematical problem-solving and graphing opportunities in the teaching and learning of Mathematics. According to the National Council of Teachers of
Mathematics (NCTM) (2003), computers provide convenient, accurate and dynamic drawings, graphing and computational tools. They also provide learners with opportunities to explore applications and concepts that would be tedious and time-consuming if the paper and pencil method was used. Computers can also assist learners with both mathematical computations and also facilitate Mathematics learning. The current study, therefore, is an attempt to gain more insight into the use of computers in the teaching and learning of hyperbolic graphs.

1.2 STATEMENT OF THE PROBLEM

According to Mifflin (2000), the hyperbolic graph is composed of two curves that exhibit symmetry on the system of axes. When using paper and pencil to plot such a graph on the system of axis, learners have to, among others, determine the asymptotes and ensure that the graph approaches the asymptotes without touching them. A great deal of circumspection is required of the learners to do this.

The National Curriculum Statement (NCS) (2003) also states that after learners have drawn hyperbola graphs, they should generalise the effects of the parameters on the drawn graphs. Judging from what normally happens when learners plot the hyperbolic graph, it would seem that the traditional paper and pencil method, which learners use to plot the hyperbolic graph takes longer, and, thus, affords learners little time to check the effects of the parameters. It is against this background that I intend to investigate the use of computers in the teaching and learning of hyperbolic graphs in secondary school Mathematics.
1.3 PURPOSE OF THE STUDY

The purpose of the study was to investigate the use of computers in the teaching and learning of hyperbolic graphs in Grades 10 to 12. The study sought to address the following questions:

- What views do learners have about the use of computers to learn hyperbolic graphs in Mathematics?
- What views do teachers have about the use of computers to teach hyperbolic graphs in Mathematics?

In addition, the study also addresses the following sub-questions:

- What are the advantages and disadvantages of using computers to teach and learn hyperbolic graphs?
- How are computers used in the teaching and learning of hyperbolic graphs?

1.4 SIGNIFICANCE OF THE STUDY

This study undertakes to contribute to the good performance of learners in Mathematics in the District of Vhembe. The Department of Education is trying by all means to improve results in Mathematics but to no avail. Mathematics plays a pivotal role in a learner’s future. According to Tarmizi, Ayub, Bakar and Yunus (2010), computers can enhance understanding of abstract mathematical concepts. This study investigates the use of computers in the teaching and learning of hyperbolic graphs in Mathematics.

In my capacity as a subject advisor, I realised that learners struggle with graphs. This, in turn, results in them developing a negative attitude towards graphs in Mathematics. This study aims to encourage many learners to love Mathematics. Tarmizi, Ayub, Bakar and Yunus (2010), in their investigation on the use of Autograph software in the study of calculus in secondary school level, observe that learners who integrate Mathematics learning with computers enjoy their lessons.
There has been an advocacy for the use of computers in Mathematics education. Despite the possible gains this move may bring about, the challenge remains the teacher and learner’s readiness and preparedness to buy-in on this initiative. The study, therefore provides, insight into the views of teachers and learners about the use of computers in the teaching and learning of Mathematics. In particular, the study illustrates the extent to which teachers and learners feel ready and confident to use computers.

The study also provides further insight into the advantages and disadvantages of integrating computers into the teaching and learning of Mathematics.

It is anticipated that the investigation into the use of computers in the teaching and learning of hyperbolic graphs will help facilitate and, thus, improve Mathematics results. The result of this research will be made available to schools so that they can improve the understanding of learners in the area of graphs.

The following people will benefit from the study: Learners, teachers and parents. Learners will learn graphs in a simplified manner, using computers. Teachers’ work will be simplified as the teaching of graphs will be made easier. Parents will also benefit as the success of learners would bring joy to them, and they, in turn, will give their support to school programmes within their communities.

1.5 DEFINITION OF KEY TERMS

The section below discusses the working definitions in this study.

- **Computer**
  This refers to an ordinary desktop or laptop which uses a software package.
• **Software**
  My study will follow the definition developed by the Radmaste Centre (2008), which states that software refers to programmes that make the computer perform different tasks.

• **Autograph**
  Autograph is a software package that can be used in Mathematics to draw graphs. Butler (2008) indicates that it is a dynamic software which is effective and efficient. It is also enjoyable and fun to use by both teachers and learners.

• **Microsoft Excel**
  MS Excel is defined by Hallberg (1997) as a programme which makes extensive use of the graphical user interface such as menus, buttons, icons, and many different mouse pointers. This is a programme that uses spread sheets; one can draw graphs and do calculations. This program can be used to draw graphs of all kinds.

• **Heymath**
  This is a software package used in the teaching and learning of grades R-12 Mathematics in some schools in Vhembe District, Limpopo Province of South Africa.

• **Hyperbolic function defined**
  Hyperbola is defined as the set of all points in a plane such that the absolute value of the difference of the distances from any point on the hyperbola to two given points, called foci, is constant (seehttp://www.mrperezonlinemathtutor.com

• **Technology**
  Your Dctionary.com defines technology as the application of science or knowledge to commerce and industry. The dictionary further indicates that the biggest applications of this type are computers and the internet. In this study, technology refers to desktop computers or calculators and laptops.
1.6 LIMITATIONS OF THE STUDY

The following was identified as a research limitation within the study:

- Some of the learners had poor computer skills and I had to teach them basic computer skills.

1.7 LAYOUT OF THE DISSERTATION

The dissertation consists of 5 chapters that have been arranged as follows:

- Chapter One provides a general overview of the study. It introduces the problem of the study, research questions, significance of the study and the definitions of the terms used in the study.
- Chapter Two is a review of literature related to the research problem. It is based on the research questions of the study.
- Chapter Three provides the research design and methodology employed in the study.
- Chapter Four provides a detailed report of the results obtained during the collection of data.
- Chapter Five gives a summary of the findings and analyses them. It also gives the conclusions and recommendation of the study.
CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 INTRODUCTION

The review of related literature to this study is organised under the following subheadings: The use of computers in the teaching and learning of Mathematics; Learning of Mathematics with computers versus the traditional paper and pencil method; The benefits of learning Mathematics with computers; The effectiveness of teaching Mathematics with computers; Computers in Mathematics classroom; Impact of computers in teaching and learning Mathematics; Using graphing software to teach Mathematics; Learning Mathematics with Autograph and Heymath Software; Review of related empirical studies; and Conceptual framework of the study.

2.2 THE USE OF COMPUTERS IN THE TEACHING AND LEARNING OF MATHEMATICS

There are studies that have investigated the use of computers in the teaching and learning of Mathematics (Berger, 2010; Inan & Lowther, 2010; Liu, 2010). Berger (2010) looked into the use of a computer algebra system (CAS) to solve Mathematics tasks. Liu (2010) used a simulation-based computer-assisted learning (CAL) to correct misconceptions about the concept of correlation in statistics. Inan and Lowther (2010) examined factors affecting the integration of laptops into classroom instruction.

The effects of computer use on learners’ achievement in Mathematics and their understanding of mathematical concepts have also been researched on (see, for example, Goos & Bennison, 2007; Alper, 2009). Support for computer use in secondary school Mathematics is also found in Australia, Brazil and Turkey to mention a few (Alper, 2009; Goos & Bennison, 2007; Baldin, 2002).
Research on the use of computers to teach learners show improved achievement (Alper, 2009). Meta-analyses give support to the use of computers to study Mathematics (Kadiyala & Cranes, 1998). Jeffries (1989) noted that numerous meta-analyses in the use of computer-aided learning (CAL) of Mathematics have resulted in learners demonstrating a more favourable attitude towards learning with computers than with direct instruction.

Experience has taught me that teachers in schools, especially in Vhembe District, often complain about the amount of time they spend on lesson preparations. According to Yushau, Mji and Wessels (2003), this challenge can be addressed as computers can be utilised to organise Mathematics instruction. This, by itself, would make teachers spend less time preparing presentable material for their classrooms.

Isikal and Askar (2005) and Suharwoto (2006) put forward that using computers as a learning tool improves Mathematics achievement of learners. Computers stimulate learners to be active in the Mathematics classroom. Raines and Clarke (2011) indicate that learners are generally attracted to computers.

Teachers also enjoy using computers in the teaching of Mathematics. Cooper and Norton (2001) point out that computer improve teaching and learning of content areas by increasing motivation for collaborative participation by learners. The role of teachers shifts into that of facilitators instead of being the source of all knowledge. Therefore, computers seem to be beneficial in the teaching and learning of mathematics.

Even though there are many advantages associated with the teaching of Mathematics using computers, there are however, also some disadvantages.

Lack of access to computers by most learners, make it difficult to use computers to support learning. This is supported by Belland (2009), who argues that, barriers to
teaching with computers include lack of resources such as knowledge, skills and availability of computers.

Tarmizi, Ayub, Bakar and Yunus (2010) point out that, learning to use computer software, can also divert the focus of learners away from the content to be learned. Teachers also need to be trained on how to use computers, in order to teach learners successfully with computers. This is supported by Belland (2009), who points out that greater training in computer skills can remove the barriers that can stand in the way of successfully teaching Mathematics using computers. Teachers have an increased responsibility of equipping themselves with skills of using computers in the classroom. Agyei and Voogt (2012) confirm that it is a challenge for teachers to extend their knowledge, beliefs and dispositions, in order to teach using computers. Persson (2011) argues that the problem with computers is that less able learners learn less because they still have to understand how to use computers.

The current study, however, investigates the use of computers in the plotting of hyperbolic graphs.

2.3 LEARNING OF MATHEMATICS WITH COMPUTERS VERSUS THE TRADITIONAL PAPER AND PENCIL METHOD

Traditionally, graphs in Mathematics were learnt through the paper and pencil method. Teachers also employed this approach to teaching graphs. This method has proved to be ineffective as learners do not perform well in graphs. This is supported by Lin (2008) who pointed out that pre-service teachers expressed the desire to integrate the use of computers in their classroom instruction. He further argues that using Mathematics textbooks often creates a dull classroom. Involving learners in hands-on activities, where they use computers as resources, will lead to learners understanding content. Raines and Clarke (2011) support the use of computers over traditional methods of teaching Mathematics when they insist that learners are generally attracted to
computers. They further point out that learners are eager to participate in classroom activities in computer-intensive classes.

Just like any other method of teaching, challenges will always be there. However, many benefits, as indicated by the studies cited above, surpass these challenges. Persson (2011) found that when teaching a computer-intensive class there are learners who may become proficient in the use of computers and mathematical software, without grasping the mathematical concepts, in which are the main focus. Persson further points out that learners who encounter difficulties in using computers may be disadvantaged in learning Mathematics effectively. A major challenge is that, in developing countries, there are very few classrooms with computers.

2.4 THE BENEFITS OF LEARNING MATHEMATICS WITH COMPUTERS

There are high expectations for the use of computers in learning Mathematics. In England, USA, Singapore, Canada, Hong Kong and Korea where computers are made use of in learning Mathematics, learners perform well (Ruthven & Hennessey, 2002). Ruthven and Hennessey also indicate that for the majority of other countries where there is minimal use of computers, performance in Mathematics is low.

Computers in Mathematics teaching have brought a change in the teaching and learning of Mathematics. According to Goldenberg (2001), computers have made some topics accessible and provided new ways of representing and handling mathematical information. Computers can create an atmosphere where learners can construct mathematical concepts (Gebrekal, 2006). In the computer classroom, the instruction can change to concept development and problem-solving since these tools remove the burden of lengthy calculations.

Computers enable learners to draw graphs much easier, quicker and more accurate. They also help them to devote more time to analysing the graphs. Another benefit of
computers, as suggested by Fey (1989), is that they facilitate learners’ progression from concrete thinking to abstract ideas.

Computers also provide a lot of information in the classroom that is useful in solving complex problems. The problem of visualisation can be removed as the computer provides pictures and graphs clearly. Yushau, Mji and Wessels (2003), in a study on creativity and computers in the teaching and learning of Mathematics, found that computers can give learners a more self-reliant role in their own education and make learners become more active agents in their education, thus making them independent learners. They further indicate that computers can simulate projects that teach learners teamwork, problem-solving, and critical thinking, as well as increase enthusiasm for learning. Computers provide learners with alternative modes of teaching for the same subject.

Raines and Clarke (2011) indicate that learners working with the appropriate computer software can work with more graphs in a short space of time. One other reason why the study is conducted is to improve the performance of learners in Mathematics. Computers seem to bring us hope. The studies cited above have presented numerous benefits of using computers in Mathematics.

However, it should be noted that even though computers have the potential to improve the teaching and learning of Mathematics, the onus still lies with the teacher to ensure proper use of computers, in order to optimise the resulting benefits. The current study, therefore, investigates how computers are used in the teaching and learning of graphs in Mathematics.

2.5 THE EFFECTIVENESS OF TEACHING MATHEMATICS WITH COMPUTERS

The use of computers in the Mathematics classroom by teachers is being promoted worldwide. According to Berger (2010), various forms of technology may promote
learners understanding of Mathematics. This is supported by Kissane and Kemp (1998) who indicate that nationally and internationally, education researchers have expressed high expectations for the potential of computers to improve the teaching and learning of Mathematics. According to Cooper and Norton (2001), computers play an increasingly vital role in assisting teachers in the classroom.

Kim, Lee, Spector and De Meester (2013), in the study on Teacher beliefs and technology integration, claim that there is an enormous contribution of computer development to all facets of our lives. They further indicate that in the field of education, teachers are concerned with how to integrate computers into instruction to improve the quality of Mathematics instruction and also enhance learners’ performance. A research finding on the use of computers in the teaching and learning of Mathematics indicates tremendous potential to improve Mathematics education (Yushau, Mji & Wessels, 2003).

Yushau, Mji and Wessels (2003) found that using computers in the teaching and learning of Mathematics can empower and provide learners with tools necessary to promote creativity. The current study will show how computers can assist teachers to develop a classroom situation that stimulates learner creativity. Yushau et al, further indicate that having access to a computer is the greatest advantage a teacher can have because of its versatility.

Most teachers in the schools in Vhembe District complain about making lesson preparations in Mathematics. This challenge can be addressed as the computer can organise Mathematics instruction, resulting in teachers spending less time preparing presentable materials for their classrooms. Learners like computers as they appeal to the eye, ear, feeling and taste and therefore, can widen and enrich the content and scope of the teachers and learners educational experiences. The sight or visualisation barrier is overcome with computers.
Computers provide easier and clearer illustrations than those made by a teacher. Computers, especially in the area of graphs, can be an accurate tool of drawing graphs.

According to Raines and Clarke (2011), working with appropriate computer software can pack a large amount of graphing experience into a relatively short space of time. Computers address the time factor in teaching Mathematics, enabling teachers to finish the syllabus in time.

According to NCTM (2000), computers can help learners to learn Mathematics. They further point out that, the graphic power of technological tools affords access to visual models that are powerful, but that many learners are unable or unwilling to generate independently.

Moila (2006) has also found the benefits of using Mathematics software to include the following:

- Promoting learners’ higher order thinking skills. Mathematical games and simulations help learners to apply mathematical ideas to problem situations;
- Developing and maintaining learners’ computation and communication skills;
- Introducing learners to the collection and analysis of data;
- Facilitating learners algebraic and geometric thinking; and
- Showing learners the role of Mathematics in an interdisciplinary setting. Integrated Mathematics packages allow learners opportunities to explore problem-based learning.

Moila further indicates that even though there are benefits in using computers in teaching Mathematics there is need to check how teachers and learners use computers, as well as the effect computers have in the Mathematics teaching and learning environment.
Suharwoto (2006) explains that the benefits of using computers include increased accuracy and speed in data collection and graphing, real-time visualisation, interactive modeling of mathematical processes, ability to collect, compute, and analyse large volumes of data, collaboration for data collection and interpretation, and more varied presentations of results. According to Thomas, Bosley, Delos Santos, Gray, Hong & Loh (2006), computers are used for both investigations and skill development.

It is worth noting that computers help those learners with a problem of sight. That is why, in this study, software which will enable an investigation of the effects of computers in the teaching of hyperbolic graphs in Mathematics will be considered. Policy makers should start to take this issue seriously and design materials to teach Mathematics using computers.

Isikal and Askar (2005) investigated the effect of spreadsheet and dynamic geometry software on Mathematics achievements and Mathematics self-efficiency. The results indicate that using computers effectively as a learning tool improves Mathematics achievement of the learners. Olkun, Altun, & Smith (2005), in the study on Computers and 2D geometric learning of Turkish fourth and Fifth grades, found that learners without computers at home initially had lower geometry scores. Olkun et al. (2005) then suggests that in schools, it seems more effective to integrate mathematical content and computers in a manner that would enable learners to do playful mathematical discoveries.

Despite the benefits mentioned above, the study will also involve the observation of teachers and learners in the classroom. This will provide ample information on what actually transpires in the classroom when computers are used.
2.6 COMPUTERS IN MATHEMATICS CLASSROOM

Thomas, Bosley, Delos Santos, Gray, Hong and Loh (2006) found that when computers are used in Mathematics classrooms they enable teachers to put more emphasis and focus on mathematical ideas and concepts that learners have to learn rather than on the facets and stages of the lessons given that the entire lesson is offered by a computer. Teachers, therefore, have to know about a computer and how it works.

It is these computer skills that help teachers enhance their teaching, thus making them effective. If a teacher cannot use a computer efficiently, expeditiously and appropriately, the quality of learning tends to be adversely affected. In South African schools, where computers are available, a teacher who plans to use computers and is deficient in computer skills may not be able to plan and structure the lesson accordingly. In particular, the activities, facets and stages of a lesson cannot be properly organised and coordinated to yield a flowing and well-articulated lesson.

Doerr and Zangor (2000) and Godwin and Sutherland (2004) indicate that the teacher plays a crucial part in lessons involving the use of computers because he has to structure and shape the computer tasks and learning activities. They add that teachers provide suitably pre-structured lesson tasks and help learners interpret the results mathematically. Tarmizi, Ayub, Bakar & Yunus (2010) points out that when a teacher uses a computer in his teaching, the way the lesson is presented tends to be different from the usual teacher-centred way of teaching. Perhaps, it is for this reason that Tarmizi et al. consider a computer to be a change agent because it prompts the teacher to adopt new ways of teaching.

Of concern though, as Suharwoto (2006) points out, is whether introducing computers in a classroom also improves learning and thus learner achievement. Probably it is this concern that has led Rowlett (2013) to argue that the focus should not be on the preference or otherwise of computers. Instead, it should be on the learning
opportunities and difficulties that tend to go with the use of computers in the teaching of Mathematics.

Clements (2000) insists that computers in the classroom contribute to cognitive development. He further explains the different ways in which computers can be introduced in a classroom, and this is in agreement with the research conducted by Means and Olson (1995), Taft (2000) on the application or uses of computers in the classroom. According to them, technology takes the following form:

- Training tool: Learners can use technology in online, quizzes, drills and practice software, or programs that guide learners through specific concepts or problems, serving as a tutor.
- Research tool: Learners can use technology in exploring and accessing information, from online resources, networked libraries, and CD-ROMS;
- Intellectual development tool: Learners can use the computer to construct and produce a variety of information through engaging in interactive games and real life simulations; and
- Communication tool: Learners can use the technology as a medium of communication through the different network levels that are available.

Moila (2006) points out that teachers should prioritise the goals and purpose of their lessons and make the selection of appropriate computer programmes to use in the teaching secondary. She further states that it could eliminate the use of technology in a wrong or less than successful manner in the classroom. The Department of Education (2003) indicates that effective use of computers can enhance creativity, problem-solving, high order thinking skills and reasoning. Capper (2003) adds that computers can facilitate the achievement of educational goals. It is against this background that the current study was being pursued.
2.7 IMPACT OF COMPUTERS ON THE TEACHING AND LEARNING OF MATHEMATICS

According to Tarmizi, Ayub, Bakar & Yunus (2010), computers in education have a huge impact on learners worldwide. They further allude to the fact that learners learn differently, and that the computer is there to assist learners who have difficulties in learning. Computers, therefore, can enhance learning when integrated properly in the teaching and learning of Mathematics.

The use of computers as a tool facilitates communication among learners and encourages them to play a more active role in a lesson (Tarmizi, Ayub, Bakar & Yunus, 2010). Tarmizi et al. further highlight that the role of learners in a computer-oriented lesson is to actively generate, process, and manipulate knowledge. The use of computers enables more learners to be active processors of knowledge, to appropriately sort out the given knowledge and to be able to act accordingly on the knowledge being considered than would be the case in typical teacher-led lessons. Learners are in a position to define their goals, make design decisions and evaluate their progress through the aid of computers (Tarmizi, Ayub, Bakar & Yunus, 2010).

The teachers roles change and they are no longer the centre of attention as dispensers of information, but rather they play the role of facilitators. As learners work on their computer-supported products, the teacher provides necessary assistance to learners and guides them through the activities and stages of a lesson by monitoring what they are doing during the lesson.

According to Prepelita-Raileanu (2008), teachers have to be provided with training that is relevant and one which concurs with the latest types of computers and computer software. Butler (2008) indicates that computers have changed the way classrooms operate, from being teacher-centred to being more interactive and participatory. It is for this reason that, Butler argues that computers have the potential to develop a better
understanding of abstract mathematical concepts because they provide visuals or
graphic representations of what is being taught. Abu Baka, Tarmizi, Ayub & Yunus
(2010) have found that learners learning Mathematics through the use of computers
enjoy their lessons more than their counterparts in traditional lessons where computers
are not used. Learners in South African schools nowadays are surrounded by computers
and, using computers in our schools hopefully, will give us the desired results.

2.8 USING GRAPHING SOFTWARE TO TEACH MATHEMATICS

The area on graphs in Mathematics is challenging to learners (Persson, 2011). The
current study, therefore, looks into the use of computers in the teaching and learning of
Mathematics. Ruthven, Hennessy and Deanery (2008) insist that graphing technology
can contribute to an effective working process and improve production by making it
easier to produce graphs accurately and rapidly. This can increase the efficiency and
pace with which related topics can be taught and learned. Ruthven et al. further
indicates that computers can help us to overcome learning difficulties and build
assurance, through making graphing tasks more accessible to learners who have
difficulties with organisation and presentation.

Computers play the role of supporting processes of checking, trialing and refinement,
through enabling lesson tasks based on trial and improvement, and supporting
mathematical speculation and experimentation within and beyond the lesson agenda
(Ruthven, Hennessy & Deaney, 2008).

The learners who use graphing software to draw graphs have the advantage of
checking the effects of parameters on the graph. This is supported by Ruthven,
Hennessy and Deanery (2008). According to Ruthven et al. computers can help with
overarching issues and accentuate important features, through helping to bring out the
effects of altering particular coefficients or parameters in an equation on the properties
of its graph, and through facilitating comparison of gradients and examination of
limiting trends. Thus, I argue that computers can help learners by reducing laborious written work, and increase the immediacy and interactivity of classroom tasks.

The study by Ruthven, Hennessy and Deaney (2008) illustrates ways in which teachers, in the course of appropriating graphing software, adapt their classroom practice and develop their craft knowledge. Ruthven et al. specifically showed how teachers establish a coherent resource system incorporating software-mediated lesson tasks aligned with teaching goals, and supported by a common repertoire of suitable graphing techniques. According to Persson (2011), teachers mentioned more risks of depending on computers in studying graphs. Amongst the risks mentioned were the fact that learners have less understanding compared to those using paper and pencil. In the current study, the Autograph and Heymath software packages are considered as resources to help learn how to make hyperbolic graphs.

2.9 LEARNING MATHEMATICS WITH AUTOGRAPH AND HEYMATH SOFTWARES

Autograph environment has 2D and 3D graphing capabilities for topics such as transformations, conic sections, vectors, slope, and derivatives (Abu-Baka, Tarmizi, Ayub & Yunus, 2010). Autograph can animate and this enables the user to observe how graphs, equations, and calculations are constructed. Abu-Baka et al. (2010) further mention that autograph software evolved in the Mathematics classrooms of Oundle School, in the United Kingdom. This 3rd version has come of age to embrace all the possibilities, its use as a drawing resource of statistical graphs, and vectors, as well as transforming shapes. Autograph software enables users to change and animate graphs, shapes or vectors already plotted to encourage understanding of the concept. The software programme also uses colour and animation. Thus the autograph software has the potential to be an excellent teaching aid.
Integrating Autograph in Mathematics teaching and learning might increase the effectiveness and improve the quality of teaching. I, therefore, assert that Autograph is an extremely useful educational tool for both Mathematics teachers and learners because it has the potential to play a much more facilitating role in lesson presentation, and it can provide learners with visual demonstrations that can be very helpful when learning a concept.

Another software package for teaching graphs in Mathematics is the Heymath. Stat (2005) describes Heymath as the Web-based platform that enables learners and teachers to learn from the best trained teacher in the world. Heymath materials are accompanied by animated lessons that learners can do on their own.

According to a report by Mathematics Science and Technology (MST) (2011), Heymath is a world class E-Learning programme that supports the work of teachers and helps learners build a strong foundation in Mathematics. The MST report further states that the Heymath is used by learners in over 55 countries, and that it has been a leading programme in Singapore for the past ten years. It is also used by schools in India and South Africa.

In the Limpopo Province, 120 secondary schools had the Heymath programme installed. Subject advisors in Mathematics were trained in this programme so that they in turn would be able to support schools with this programme (Report by Mathematics Science and Technology (MST) 2011). (See Appendix L).

Thus the main focus of my study is on the use of computers using Autograph and Heymath software programmes in the teaching and learning of hyperbolic graphs.
2.10 REVIEW OF RELATED LITERATURE

Thomas (2006), in a longitudinal study carried out in the secondary schools in the Caribbean on how Mathematics teachers use computers, found that computers were not used effectively. In 2005, teachers in New Zealand Secondary Schools were asked about the advantages and disadvantages of using computers in teaching Mathematics and they came up with the following:

- Eight (8%) percent of the teachers believed that computers aided understanding compared to 32% who thought it made working quicker or more efficient; and
- Sixteen point eight percent (16.8%) claimed that it impeded learning or understanding. This is in agreement with Manoucherhi’s (1999) findings which states that teachers are not convinced about the usefulness of computers in their instruction.

Clarke (2007), in the study on exploring the use of computer technology in a Caribbean context, concluded that the Caribbean setting faced many similar challenges to those in developed and developing countries when newly qualified teachers attempted to apply new technologies.

O’ Callaghan (1998) investigated how learners conceptual comprehension of graphs differed because of the method they were taught. O’ Callaghan’s framework of study was derived from the function model which consists of four components, namely modeling, interpreting, translating and reifying. Three classes of algebra learners were sampled. One of these three classes used a computer-intensive algebra programme (CIA) and the other two were traditional teacher-instructed classes (TA). Results from the quantitative analysis showed that the CIA learners demonstrated better overall knowledge of graphs, components of modeling and interpretation.

Analysis of the interviews showed that learners from the CIA class reacted more positively to their curriculum than the TA learners. The findings from both quantitative
and qualitative aspects of this study indicated that the CIA learners had a better understanding of the function concept.

Hollar and Norwood (1999) examined the effects of a graphing approach intermediate algebra curriculum on learners’ comprehension of the function concept. The purpose of their study was to find out whether a curriculum using hand–held graphing calculators facilitated reflection of knowledge concerning the function concept. O’Callaghan’s function test was used to assess learners’ understanding of graphs. Hollar and Norwood concluded that the learners who had access to graphing calculators had a significantly better understanding of the function concept.

Porzio’s (1999) study looked at the effect of differing emphasis in the use of multiple representations and technology on learners’ understanding of calculus concepts. This study was conducted by examining three types of calculus classes, namely: traditional calculus course, a calculus course that included the graphics calculator, and an electronic course using computers. Porzio found that learners from the course that was completely taught by a computer showed the best understanding of various calculus concepts.

Monaghan (2004) investigated what high school teachers do when they use digital technology in their lessons. Thirteen English Mathematics teachers from seven English high schools took part in Monaghan’s study. Monaghan’s findings suggest that the teacher in a technology-based lesson takes the mediator role rather than a facilitator. According to Monaghan, a mediator is a teacher who plays an active role in learners’ learning.

Farrell (1996), when investigating teachers’ use of technology in a Mathematics classroom, was able to compare the teacher’s role with and without the use of technology. Farrell found that the roles that the teachers exhibited when using computers differed from when computers were not used. The teachers displayed
managerial roles in both instances that is, when using computers and when not using them. However, Farrell realised in her study that teachers assumed the role of consultant, fellow investigator, and resource more often when using technology. Farrell then concluded that when technology was used teachers held on to their roles as managers and task setters, while taking on new roles of consultant and fellow investigators.

Zhao (2007) investigated the perspectives and experiences of 17 social studies teachers following technology integration training. Findings in this investigation showed that teachers held a variety of views towards technology integration. The teachers’ views influenced how they used technology in the classroom. Most teachers support the use of technology in their classrooms.

Challoo and Marshall (2005) examined the levels of availability, effectiveness, and utilisation of computer technology by secondary school Mathematics teachers. The study was conducted among 74 Mathematics teachers. The results indicated that teachers have problems accessing computers, and that a strong need for more curricular–based software exists. Data showed that computer technology is helpful in instructional procedures and in the student learning process.

Tarmizi, Ayub, Bakar and Yunus (2010), in their study on effects of technology-enhanced teaching on performance and cognitive load in calculus, found that learners are encouraged to learn using computer softwares. Tarmizi et al., in particular, concluded that the autograph integrated learning strategy is instructionally more efficient and thus superior to the conventional instruction strategy. The study by Tarmizi et al. (2010) shows prominent implications for the potential use of autograph software.

Raines and Clarke (2011) support the use of computers in the teaching and learning of Mathematics when they insist that integrating and using computers in the teaching of
Mathematics can encourage learners to be active in classrooms. However they also warn that teachers need to know that learners must not only master computer usage, but that they should master content as well. They conclude by stating that computers, as with any other teaching tool can be used effectively or poorly.

Agyei and Voogt (2012), in their study on developing technological content knowledge in pre-service Mathematics teachers, found that there was need to develop technological pedagogical content knowledge for pre-service teachers. They further point out that even though pre-service teachers need integration of technology with Mathematics that is not actually what is happening in the ground.

Rowlett (2013), in his study on developing a healthy skepticism about technology in Mathematics teaching, agrees that computers when placed in proper context can be useful in aiding learners to understand Mathematics. He further states that computers may not provide benefit, but that benefits may be achieved by changing the approach to one driven by the use of computers.

Although these research results are extremely encouraging, not all the results have been positive. Hall (1993), Pankow (1994), Rich (1993), Ritz (1999) and Smith (1996) reported that there were no significant differences in achievement between learners who use computers and those who do not use computers. Dunham and Dick (1994:442) also found that in a college pre-calculus course the use of graphing technology did not show improvement in learners’ understanding of graphs. Giamati (1991) reported that the use of graphic calculators affected learners’ performance negatively. According to Giamati’s report the control group of learners which did not use graphic technology understood graphical transformations and curve sketching better than the experimental group which used graphic technology. The current study intends to investigate the use of computers in the teaching and learning of hyperbolic graphs.
Results from research on the use of computers to teach learners show improved learner achievement (Alper, 2009). Alexander (1993), Chandler (1993), Durmus (2000), Funkhouser (1993), Hollar and Norwood (1999), Kulik and Kulik (1991), Graham and Thomas (2000), Quesda and Maxwell (1994) and the International Study Centre (1998) reported that learners who use computers in Mathematics obtained higher scores than those learners who did not use them. Thus the current study sought to establish how computers are used to teach problem concepts such as hyperbolic graphs.

Yushau, Mji and Wessels (2003) identified the following benefits of using computers in the teaching and learning of Mathematics:

- Computers can empower and provide learners with necessary tools for promoting creativity;
- Having access to a computer is the greatest advantage a teacher can have because of its versatility;
- Teachers can effectively address the challenge of organising Mathematics instruction and will, therefore, not spend a lot of time preparing presentable materials for their classrooms;
- With multimedia capabilities, computers, have the capabilities of appealing to the eyes, ears, feelings and taste and, therefore, can widen and enrich the content and scope of their educational experiences;
- With computers, learners can visualise mathematical concepts which are difficult to comprehend without computers;
- Computers provide easier and clearer illustrations than those teachers could make; and
- Working with appropriate computer software can pack a large amount of graphing experience into a relatively short space of time.

Computers allow learners to draw graphs more easily, quickly and accurately, as well as to manipulate the graphs, to develop and generalise about graphs (Gebrekal, 2006).
The literature shows that classrooms in which computers are used provide a conducive environment for learning. Farrel (in Dunham & Dick, 1994:443) notes that learners became more active in classrooms in which computers were used. In classrooms where computers are used, learners have the opportunity to experiment and find out for themselves, and their roles change from passive to becoming more involved in group work, real problem-solving, investigating and consulting with computers (Pollak, 1986). The current study investigated the issue of computers in Mathematics teaching and learning further.

2.11 CONCEPTUAL FRAMEWORK OF THE STUDY

The study has been conceptualised, firstly, around the fact that schools in the Vhembe District have been provided with computers to help in the teaching and learning of Mathematics. Schools in the Vhembe District use Autograph and Heymath software packages. The framework of this study emanates also from the fact that, historically, classes in the Vhembe District have always been teacher-centred. This is the approach where the teacher works one or two examples for the learners on the chalk board, and then gives them exercises based on the worked examples. Tarmizi, Ayub, Bakar and Yunus (2010) refer to the teacher-centred approach as an approach, where learners are passive recipients to the teacher’s, delivery of complete information. The teacher in this instance is the main source of information to be taught to learners. Mathematics is a subject which by nature, demands active participation by learners. Computers require learners to mainly work on their own. In other words, introducing computers in schools brings about learner-centredness. This study intends to determine, in a way, teachers and learners views about the extent to which learner-centredness prevails in their schools that have incorporated computers in the teaching and learning. Introducing computers in the schools in Vhembe District thus had challenges where teachers first had to be taught about the computers and also how to use them in teaching. It was hoped that the computers would help improve learner achievement, particularly in

A similar view is advanced by Kyriazis and Korres (2001), who argued that by introducing computers in the teaching and learning of Mathematics, the effects and weaknesses of traditional teaching would be reduced and that this would improve learner achievement. Given the potential a computer has as teaching and learning resource (Ng & Gunstone, 2002; Abu-Baka, 2005; Kimmis, 1995; & Johannesen, 2007; Goos & Bennison, 2007; Naatanen, 2007; Baldin, 2002; & Alper, 2009), the current study investigated how computers are used to teach and learn problem concepts such as hyperbolic graphs in Mathematics.

Secondly, there are trends emerging in literature on the use of computers in Mathematics teaching and learning. For example, as Goos and Bennison (2007) point out, a lot of attention has been given to examining the effects of computer use on mathematical achievement, while little attention has been placed on how teachers use computers in their teaching. As Cuban et al. (2002) explain, in some schools teachers do not use computers because of the unconducive conditions in those schools. Some of the unconducive conditions in the schools include unchanging school structures, obsession to finish the prescribed syllabus timeously, which made teachers to rely heavily on the teacher-centred instructional approach, and teachers not given sufficient and suitable training on how to use computers in the teaching and learning of Mathematics. The report by Smith-Gratto and Fischer (1999) that lack of appropriate teacher training is often considered as the main problem in using computers in teaching and learning corroborates the issue on teacher training. The issue of inadequate teacher development programmes focusing on the use of computers in teaching and learning was also noted by Moila (2006) and Marshall (2005).

Smith-Gratto and Fischer also pointed out that after training teachers on how to use computers, there is no guarantee that they will be able to integrate computers in their
teaching. This argument is also supported by Raines and Clarke (2011) who insist that teachers need to learn not only how computers are used, but also why the use of computers is important. Moila (2006) also insists that there has to be a balance between training teachers in computer use and creating awareness among teachers about the benefits of using computers in Mathematics teaching and learning.

Norton and Cooper (2001), in their study on factors influencing computer use in Mathematics teaching in secondary schools, found that teachers were reluctant to use computers in their teaching largely due to their beliefs about Mathematics, pedagogical knowledge, their knowledge of how to use computers, and the learning of Mathematics. Norton and Cooper also found that one way of solving these problems could be to develop programmes that would encourage teachers to move slowly away from their existing practices.

Another factor that tends to impede teachers from using computers in their teaching is the one that was found by Moila (2006). Moila found that there were no guidelines or policies on the use of computers in schools. Thomas (2006) points out that few secondary schools in the Caribbean had a policy on the use of computers in teaching and learning. This policy stated that computers should be used wherever possible. In this study, the issue of teaching educators to use computers was addressed.

Introducing computers in Mathematics teaching and learning calls for changes in the respective roles played by teachers and learners. Teachers become facilitators of learning while learners become active participants in the learning process. According to Wheeler (2000), teachers should engage learners in more collaborative lesson activities and encourage learners to actively participate in the learning process. The lesson activities have to be cognitively demanding and thought-provoking so that critical and creative thinking can be developed, and learners can simulate and visualise lesson activities on computer monitors. As Jarret (1998) points out, such an instructional
approach tends to bridge concrete and abstract thinking. It is against this background that the current study was pursued.
CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the methodology applied in this study. In particular, the chapter gives attention to the following aspects: research design, population, sampling and sampling techniques, instrument for data collection, data collection procedures, and data analysis.

3.2 RESEARCH DESIGN

The study followed a descriptive survey design as I was interested in determining the extent to which computers are used in the teaching and learning of hyperbolic graphs. It should be noted that the purpose of my study was to understand the phenomenon on the ground, that is, the study’s focus was to get information on the use of computers in Mathematics teaching and learning. The idea of adopting such a design is also supported by Cohen and Manion (2007:207), who insist that ‘descriptive surveys simply describe data on variables of interest’. In this study the variables of interest is the use of computers in teaching and learning hyperbolic graphs in secondary school Mathematics. Leedy (2005) asserts that the descriptive survey design is typically concerned with determining the frequency with which something occurs. Hence a descriptive survey design was chosen to attempt to find the proportion of learners who enjoys using computers in learning hyperbolic graphs.
3.3 POPULATION

In this study, the population consisted of Grade 10 to 12 learners and their teachers in schools in the Vhembe District, Limpopo Province.

3.4 SAMPLING PROCEDURES

A convenience sampling technique was used to identify schools for the current study. The total number of schools identified was nine. In each of the nine schools, I then randomly selected fifteen learners from Grades 10 to 12. Five learners were selected from each grade. Altogether 135 learners and 7 teachers completed the questionnaire in the study. Given the nature of the problem of my study and its design, I deemed the sample size appropriate.

3.5 DATA GATHERING INSTRUMENTS

I used two types of data gathering instruments. Firstly, I employed the questionnaire (see Appendix A) for learners. The questionnaire inquired on how learners use computers in learning hyperbolic graphs.

Secondly, I used the interview schedule (see Appendix B and C) to collect data from both learners and teachers. Interviews offered me an opportunity to understand the experiences of the teachers and learners.
3.5.1 Development of the Instruments

3.5.1.1 Questionnaire Instrument

In this study, questionnaires were adapted from the study by Gebrekal (2006) entitled “The influence of the use of computers in the teaching and learning of graphs in school Mathematics”.

In this study, I adapted Gebrekal’s instrument used to collect data relating to quadratic equations. The originator of the instrument concentrated on quadratic equations. Guided by this instrument, I modified the instrument in Gebrekal (2006) which focused on hyperbolic graphs. Where Gebrekal concentrated on MS Excel and RJS software, I focused on Autograph and Heymath (see Appendix A).

One questionnaire for the learners was used in the study. The questionnaire used four Point Likert-type scales and had two sections, each consisting of ten closed questions. Respondents were required to indicate the extent to which they strongly agree, agree, disagree or strongly disagree. The first set of questions dealt with personal information. The second section focused on how the learners used Autograph to learn hyperbolic graphs (see Appendix A).

The purpose of the questionnaire was to investigate the use of computers on learners’ problem solving, their motivation and attitude towards themselves and the teachers in learning hyperbolic graphs using computers.

3.5.1.2 Interview

Semi-structured interviews were made up of two schedules. One schedule was for Mathematics learners (see Appendix B) and the other one was for teachers (see Appendix C). The first three questions in the teachers’ schedule focus on how the
teachers used the computers. The fourth question focuses on the experiences of the teacher in teaching hyperbolic graphs using the computer. The 5th question inquired on the advantages of using computers when teaching graphs. The challenges teachers encounter when they use computers in teaching Mathematics were considered. The first three questions in the learners’ schedule dealt with how the learners used the computer to learn Mathematics. The fourth question dealt with the experiences of the learner in learning hyperbolic graphs using a computer. The 5th question sought to find out the advantages of using computers when learning hyperbolic graphs. The literature review considers this under the benefits of learning Mathematics with computers. The challenges learners encounter when they use computers in learning Mathematics were considered. Thirty learners who had computers at home were interviewed. These are learners who used computers to do mathematical tasks at home. Seven teachers were interviewed.

The purpose of the interview was to investigate the use of computers on learners’ attitude, motivation and problem solving in the learning of hyperbolic graphs. The researcher wanted to probe far beyond the answer to the standardized prepared questions to get more information.

3.5.1.3 Learners’ interview

The semi-structured interview schedule consisted of eight open-ended questions designed and conducted after completion of the experiment. Thirty learners were interviewed in this study. A tape recorder was used to record the responses.

3.5.1.4 Teachers’ interview

All seven teachers who participated in the study were interviewed. The purpose of the interview was to gather the teachers’ views on the use of computers in the teaching hyperbolic graphs in Mathematics.
3.6 VALIDITY AND RELIABILITY OF INSTRUMENTS

The validity and reliability of the instruments used in this study is the section discussed below.

3.6.1 Validity

In addition to piloting the questionnaires, it was also given to an established researcher to validate. All the suggestions and recommendations were taken into consideration to ensure validity. The content validity of the questionnaire instrument was carried out. The researcher wanted to assess the learners’ interest in learning hyperbolic graphs with computers. The instrument indicates a high content validity as high percentages of learners showed interest in using computers to learn hyperbolic graphs.

3.6.2 Reliability

The Cronbach alpha was then used to determine the internal consistency of the questionnaires. The instrument was administered to 35 learners in pilot study. The reliability coefficient obtained for section B and section C was an overall alpha of 0.71.

3.7 PILOT STUDY

A pilot study was conducted in one of the schools where computers were used in the teaching and learning of Mathematics in one of the districts in Limpopo. The questionnaire was administered to Grades 10 to 12 learners. The respondents were asked to complete a four point Likert type scale questionnaire and indicate the extent to which they strongly agree, agree, strongly disagree and disagree with the statement. From this, the frequencies and percentage distribution of frequencies of learners’ responses to items were calculated and this was followed by a reliability analysis (see Appendix I).
The data gathered through the questionnaire in the pilot study strongly supports the argument that computers are useful in teaching and learning hyperbolic graphs. The results from learners’ interviews show that learners enjoy learning hyperbolic graphs using computers. However a few learners did not favor the method of using computers in learning hyperbolic graphs. They indicate that in tests and examinations computers are not allowed in the exam rooms and this could create problems if one depends on them entirely.

### 3.8 IMPLICATIONS OF THE PILOT STUDY FOR THE MAIN STUDY

Based on the results of the pilot study, I concluded that the main study would be feasible. The descriptive survey design was appropriate for the nature of the problem I sought to address. The instruments used were able to give the desired data to address the research questions.

### 3.9 DATA GATHERING PROCEDURES

Following the outcomes of the pilot study, I then embarked on the data collection for the main study. Nine secondary schools were visited in a period of two weeks, in order to collect data. Teachers in each school helped me administer the questionnaires to learners. The questionnaire was administered to one hundred and thirty five learners in nine secondary schools. In each secondary school, the last period was used to administer the questionnaire. Fifteen learners in each school completed the questionnaire. The researcher scored the questionnaire. During study time, learners who had computers at home were interviewed in English. A video recorder was used to record learners’ responses. It took me about forty minutes to interview all the learners in each school. The teachers were then interviewed after learners’ interviews. It took me twenty minutes to interview all the teachers in each school.
3.10 DATA ANALYSIS TECHNIQUE

I used descriptive statistical analysis to analyse data from the questionnaire. Descriptive statistics summarised the general nature of the responses to the questionnaire items and the relationship between questionnaire items and responses that were closely related (Leedy 2005). Learners responded to items in the questionnaire using a four point Likert scale with the following choices: strongly disagree, disagree, agree and strongly agree. A statistician analysed the learners’ responses and gave statistical interpretation of data. The responses to questionnaire items were presented using bar charts and frequency tables. Data from the interview were transcribed (see Appendix D, F, G and H). Learners who were interviewed were all those who used computers at home to do Mathematics problems. They were thirty in number. After the transcription, I grouped the interviews into themes and categories and similar categories were then analysed and interpreted.

3.11 ETHICAL CONSIDERATION

This entails informing participants of the study about their rights in taking part, as well as making them understand the purpose of the study as indicated in the consent form in Appendix K. Letters requesting permission to carry out the study were given to the principals. All the nine principals stamped the letters and permission was granted to the researcher to conduct the study in these schools (see Appendix J for the letters). The study was ethically cleared by the university.

(a) Informed Consent

The participants were informed about the nature of the study to be conducted so that they could decide whether to take part or not. The participants were informed about the nature of the research and issues on confidentiality. (See Appendix K, for the informed consent form).
(b) Confidentiality

The information provided to the researcher is confidential and would be used for research purposes only (See Appendix K).
CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

The purpose of this chapter is to present, analyse and interpret data. Data collected in the main study are presented below. Data collected through the questionnaire are presented first, and then followed by the interview responses.

4.2 DATA FROM THE LEARNERS’ QUESTIONNAIRE

The learners responded to items in the questionnaire by indicating the extent to which they either agreed or disagreed with each item. The frequencies and percentage distribution of frequencies of learners’ responses per item were calculated followed by a reliability analysis.

The figures and tables below show the responses of learners in the questionnaire. The responses determine the extent to which learners used computers when they learned hyperbolic graphs. Figure 4.1 shows the extent to which learners agreed or disagreed with the items on the use of computers to learn hyperbolic graphs.
Figure 4.1: The extent to which learners agreed or disagreed with items in the questionnaire.
Table 4.1: Percentage average scores of learners’ responses to questionnaire items

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 1</th>
<th>Item 2</th>
<th>Item 3</th>
<th>Item 4</th>
<th>Item 5</th>
<th>Item 6</th>
<th>Item 7</th>
<th>Item 8</th>
<th>Item 9</th>
<th>Item 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>0.3%</td>
<td>5.9%</td>
<td>0%</td>
<td>1.3%</td>
<td>4%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Disagree</td>
<td>0%</td>
<td>0.3%</td>
<td>11.1%</td>
<td>6.6%</td>
<td>10.2%</td>
<td>10.2%</td>
<td>9.8%</td>
<td>10.2%</td>
<td>16.6%</td>
<td>10.3%</td>
</tr>
<tr>
<td>Agree</td>
<td>48.8%</td>
<td>68.7%</td>
<td>44.3%</td>
<td>32%</td>
<td>46.5%</td>
<td>34%</td>
<td>48.8%</td>
<td>47.2%</td>
<td>42.7%</td>
<td>49.4%</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>51.1%</td>
<td>31%</td>
<td>44.6%</td>
<td>59.4%</td>
<td>43%</td>
<td>49.9%</td>
<td>41.4%</td>
<td>41.3%</td>
<td>36.8%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Table 4.1 presents the percentage average scores of learners’ responses per item in the questionnaire.

The data in Figure 4.1 and Table 4.1 is the same but presented differently. The interpretation of the data in Figure 4.1 and Table 4.1 is presented below.

All the learners (100%) agree with item 1 that hyperbolic graphs are an interesting topic to learn using the computer software programme, Autograph or Heymath. All learners (100%) agree with item 2 that it is convenient to solve a hyperbola graph problem using the computer software programme, Autograph or Heymath. The majority (44.3% agree) and (44.6%) strongly agree with item 3 that the use of a computer software programme in learning hyperbolic graphs enables learners to create a table of values of the graphs quickly. Only 11.1% of the learners disagree that the computer is helpful in learning hyperbolic graphs and that it enables learners to create tables of value of the graphs quickly.
A substantial number of learners (59.4%) strongly agree and (32%) of the learners agree with item 4 that the use of computers in teaching hyperbolic graphs enables learners to draw graphs easily. A small percentage (6.6%) disagrees and (2.2%) strongly disagree that the use of computers in learning hyperbolic graphs enables learners to draw graphs easily. Most of the learners either agreed (46.5%) or strongly agreed (43%) with item 5 that the use of computer in learning hyperbolic graphs enables a learner to get sufficient time to investigate the nature and properties of the graphs.

A significantly smaller percentage (0.3%) strongly disagrees and (10.2%) disagree that the computers are helpful in learning hyperbolic graphs and that they enable learners to get time to investigate the nature and properties of graphs. A significantly larger percentage of learners strongly agree (49.9%) or agree (34%) agree with item 6 that the computers are helpful in learning hyperbolic graphs and that they encourage learners to work in groups. A smaller number of learners (5.9%) strongly disagree and (10.2%) disagree that computers are convenient in encouraging group work.

A substantial number of learners (41.4%) strongly agree and 48.8% of the learners agree with item 7 that the use of computers in learning hyperbolic graphs gives the learners the opportunity to share their views with their peers. A small percentage (9.8%) disagree that the use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their peers. A fair number of learners (41.3%) strongly agree and 47.2% of the learners agree with item 8 that the use of computers in learning hyperbolic graphs gives learners the opportunity to share their views with their teachers. A small percentage (10.2%) disagrees and 1.3% strongly disagree that the use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their teachers.
The majority agrees (42.7%) and 36.8% strongly agree with item 9 that the use of a computer software programme in learning hyperbolic graphs motivates learners to work independently on their problems. Only 4% of the learners strongly disagree and 16.6% of the learners disagree that the computer is helpful in motivating learners to work independently on their problems.

A significantly large percentage of learners (40%) strongly agree and 49.4% agree with item 10 that the computers are helpful in learning hyperbolic graphs and giving learners opportunities to engage with real life mathematical problems. A smaller number of learners (10.3%) strongly disagree and 0.3% disagree that computers are convenient in giving learners the opportunity to work with real life mathematical problems.

In summary, data in Figure 4.1 and Table 4.1 above show us that a high percentage of learners agree that computers are useful in learning hyperbolic graphs. Only a small percentage of learners disagrees that computers are useful in learning hyperbolic graphs.

In Figure 4.2 below, the learners’ responses have been categorised into agree or disagreed. That is, each of the positives (strongly agree and agree) were grouped together and likewise the negatives (i.e. disagree and strongly disagree). Figure 4.2 shows how learners agreed or disagreed with items on the use of computers to learn hyperbolic graphs.
Fig 4.2: The extent to which learners agreed or disagreed with items in the questionnaire.
Table 4.2: Percentage average scores of learners’ responses per item

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 1</th>
<th>Item 2</th>
<th>Item 3</th>
<th>Item 4</th>
<th>Item 5</th>
<th>Item 6</th>
<th>Item 7</th>
<th>Item 8</th>
<th>Item 9</th>
<th>Item 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>0%</td>
<td>0.3%</td>
<td>11.1%</td>
<td>8.6%</td>
<td>10.5%</td>
<td>16.1%</td>
<td>9.8%</td>
<td>11.5%</td>
<td>20.5%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>100%</td>
<td>99.7%</td>
<td>88.9%</td>
<td>91.4%</td>
<td>89.5%</td>
<td>83.9%</td>
<td>90.2%</td>
<td>88.5%</td>
<td>79.5%</td>
<td>89.4%</td>
</tr>
</tbody>
</table>

Table 4.2 presents the percentage average scores of learners’ responses per item in the questionnaire.

Data in Figure 4.2 and Table 4.2 is the same data presented in graph format and table format. The explanation of these data is given below. In this discussion, strongly disagree and disagree is referred to as disagree and strongly agree and agree as agree.

All the learners (100%) agree with item 1 that a hyperbolic graph is an interesting topic to learn using the computer software programme, Autograph or Heymath. The majority of learners (99.7%) agree with item 2 that it is convenient to solve a hyperbola graph problem using the computer software programme, Autograph or Heymath. A significantly small percentage (0.3%) disagrees that it is convenient to solve a hyperbola graph with a computer.

The majority (88%) agree with item 3 that the use of a computer software programme in learning hyperbolic graphs enables learners to create a table of values of the graphs quickly. Only 11.1% of the learners disagree that the computer is helpful in learning
hyperbolic graphs and that it enables learners to create tables of values of the graphs quickly.

A substantial number of learners (91.4%) agree with item 4 that the use of computers in learning hyperbolic graphs enables learners to draw graphs easily. A small percentage (8.6%) disagrees that the use of computers in learning hyperbolic graphs enables learners to draw graphs easily.

The majority (89.5%) agree with item 5 that the use of computers in learning hyperbolic graphs enables a learner to get sufficient time to investigate the nature and properties of the graphs. A significantly small percentage (10.5%) disagrees that computers are helpful in learning hyperbolic graphs and that they enable learners to get time to investigate the nature and properties of graphs.

A significantly large percentage of learners (83.9%) agree with item 6 that the computers are helpful in learning hyperbolic graphs and that they encourage learners to work in groups. A smaller number of learners (16.1%) disagree that computers are convenient in encouraging group work.

A substantial number of learners (90.2%) agree with item 7 that the use of computers in learning hyperbolic graphs gives the learners the opportunity to share views with their peers. However a small percentage (9.8%) disagrees. A large number of learners (88.5 %) agree with item 8 that the use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their teachers, while a small percentage (11.5%) disagrees.

The majority (79.4%) agrees with item 9 that the use of a computer software programme in learning hyperbolic graphs motivates learners to work independently on their problems. Only 20.6% of the learners disagreed.
A significantly large percentage of learners (89.4%) agree with item 10 that computers are helpful in learning hyperbolic graphs and that they give learners an opportunity to engage with real life mathematical problems. A smaller number of learners, however (10.6%) disagree that computers are convenient in giving learners opportunity to work with real life mathematical problems.

In summary, data in figure 4.2 and table 4.2 above show that a high percentage of learners agrees that computers are useful in learning hyperbolic graphs. Only a few learners indicate that computers are not useful in learning hyperbolic graphs. Even though many learners agree that computers are useful in learning hyperbolic graphs, it is noted, that, since the Likert-scale was used, in responding to the questionnaires, what learners believe in, is not necessarily what they sometimes do.

### 4.2.1 Analysis of the Learners’ Questionnaire Responses per Item

The focus in this section is on analysing the learners’ responses item by item. Furthermore, the learners’ responses have been categorised into agree or disagree. This means that each of the positives (strongly agree and agree) were put together and likewise the negatives (disagree and strongly disagree).

**Question 1: Hyperbolic graph is an interesting topic to learn using a computer software programme (Autograph and Heymath)**

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>0%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>100%</td>
</tr>
</tbody>
</table>
All learners agree that hyperbolic graph is an interesting topic to learn using a computer. This means that computers make the learning of hyperbolic graphs fun and enjoyable.

**Question 2:** It is convenient to solve a hyperbola graph problem using a computer software programme (Autograph or Heymath)

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>0.3%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>99.7%</td>
</tr>
</tbody>
</table>

A significantly large percentage of learners (99.7%) find it convenient to solve hyperbolic graphs using computers. This implies that learners find computers helpful when they solve hyperbolic graphs.

**Question 3:** The use of a computer software programme (Autograph or Heymath) in learning hyperbolic graphs enables learners to create tables of values of the graphs quickly

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>11.1%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>88.9%</td>
</tr>
</tbody>
</table>

A large percentage of learners (88.9%) find computers helpful in learning hyperbolic graphs and in enabling one to create tables of values of the graphs quickly. However a
few learners (11.1%) do not find computers helpful in enabling them to create tables of the graphs quickly. This implies that many learners find computers helpful in creating tables of the graphs, while a few learners do not find computers helpful.

**Question 4:** The use of a computer in learning hyperbolic graphs enables learners to draw graphs easily

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>8,6%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>91,4%</td>
</tr>
</tbody>
</table>

A significantly large percentage of learners (91.4%) find it convenient to draw hyperbolic graphs using computers. This implies that learners find computers helpful when they draw hyperbolic graphs.

**Question 5:** The use of computers in learning hyperbolic graphs enables a learner to get sufficient time to investigate the nature and properties of the graphs

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>10,5%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>89,5%</td>
</tr>
</tbody>
</table>

A large percentage of learners (89.5%) find computers helpful in learning hyperbolic graphs and in enabling them to get sufficient time to investigate the nature and
properties of the graphs. However, a few learners (10.5%) do not find computers helpful in enabling them to get sufficient time to investigate the nature and properties of the graphs.

This implies that many learners find computers helpful in learning hyperbolic graphs and in enabling them to get sufficient time to investigate the nature of graphs, while a few learners do not find computers helpful.

**Question 6: The use of computers in learning hyperbolic graphs encourages learners to work in groups**

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>16,1%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>83,9%</td>
</tr>
</tbody>
</table>

A high percentage of learners (83.9%) find computers useful in learning hyperbolic graphs. They also give them time to work in groups. A small percentage (16.1%) does not find computers useful. This indicates that many learners find computers useful in learning hyperbolic graphs in that more time becomes available for learners to work in groups.
**Question 7**: The use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their peers

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>9,8%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>90,2%</td>
</tr>
</tbody>
</table>

A significantly large percentage of learners (90.2%) find computers helpful in learning hyperbolic graphs and they give them opportunity to share views amongst themselves. A small percentage of learners (9.8%) do not find computers useful in learning hyperbolic graphs or in giving them an opportunity to share views amongst themselves. This implies that computers are useful in learning hyperbolic graphs and in providing learners with time to share their views amongst themselves.

**Question 8**: The use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their teachers

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>11,5%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>88,5%</td>
</tr>
</tbody>
</table>

A notably high percentage of learners (88.5%) find the use of computers in learning hyperbolic graphs useful in helping them to share their views with their teachers. A small percentage of learners (11.5%) do not find the use of computers useful in giving them an opportunity to share their views with their teachers. This shows that many
learners find computers helpful in learning hyperbolic graphs as they get ample time to share their views with their teachers.

I am conscious of the fact that this information needs to be confirmed through the interviews.

**Question 9: The use of computers in learning hyperbolic graphs motivates learners to work independently on their problems**

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>20,6%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>79,4%</td>
</tr>
</tbody>
</table>

A high percentage of learners (79.4%) find computers convenient in the learning of hyperbolic graphs and they also motivate them to work independently. A small percentage of learners (20.6%) do not find computers helpful in learning hyperbolic graphs and also in giving them time to work independently. This implies that computers are helpful in learning hyperbolic graphs and in providing learners with time to work independently.
**Question 10:** The use of computers in learning hyperbolic graphs gives learners the opportunity to engage with real life mathematical problems

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>10.6%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>89.4%</td>
</tr>
</tbody>
</table>

A high percentage of learners (89.4%) find computers convenient to learn hyperbolic graphs. They also give them time to engage with real life mathematical problems. A small percentage of learners (10.6%) do not find computers helpful in learning hyperbolic graphs and also in giving them time to engage with real life mathematical problems. This implies that many learners find computers helpful in learning hyperbolic graphs and in providing them with time to engage with real life mathematical problems.

In summary the data gathered through the questionnaire in the main study strongly supports the argument that computers are useful in learning hyperbolic graphs. It confirms that the integration of computers into the teaching and learning of Mathematics is important as learners are attracted to computers. This then implies that learners will enjoy Mathematics and not fear it.

The questionnaire was administered to 135 learners. One of the questions in the questionnaire sought to find out whether learners had computers at home. Of the 135 learners 30 learners indicated they had computers. The learners with computers at home responded in the following way to how they use their computers:
Question 11: Do you use your computer at home for your school work? If yes, please explain what type of work you do with your computers

The learners’ responses to this question indicated that:

- 45.5% of the learners with computers at home use them for assignments, projects and investigations;
- 43% of the learners have access to internet and they indicated that they use computers at home to search for information they need to do their school tasks;
- 91% of the learners use their computers at home to do Mathematics; and
- 3% of the learners who have computers at home use computers for music and to watch movies.

Many of the learners’ response to the questionnaire confirmed that they use computers to do Mathematics.

4.3 REPRESENTATION AND ANALYSIS OF THE LEARNERS’ RESPONSES TO INTERVIEW QUESTIONS

Thirty learners were interviewed in the main study. The learners who use computers at home to do Mathematics were interviewed in all the nine secondary schools. The interviews were conducted during study time and took about forty minutes. I recorded the learners’ responses myself. Some learners did not respond to questions asked and when I probed them they indicated that they agreed with what other learners had said.

After the learners’ interviews, the teachers who teach Mathematics in Grades 10 to 12 were also interviewed. In some schools only one teacher taught Mathematics in Grades 10 to 12. In the transcripts the Learners are identified by L1 which refers to learner 1; L2 refers to learner 2 up to L30. In the transcripts the teachers are identified as T1 which refers to teacher 1 and T2 which refers to teacher 2 and so on. The section
below presents the responses to the interviews as well as an analysis of the learners’ responses.

Question 1: How are you being taught graphs in Mathematics?

The first question learners were asked is how they were being taught graphs in Mathematics. The responses to this question were:

- **L1**: Most of the time she starts by telling us the function, presses the mode and the table will appear and then we draw the graph.
- **L2**: When she is teaching us, she will tell us the values of x and we find y and then draw the graph.
- **L3**: They use the table method, where you have to complete the table, given x and you find y.
- **L4**: We use a calculator, press shift, it will make us a table and we use the table, then we will choose the table. They will ask us where the graph starts and end and we will plot the graph.
- **L5**: We press mode and then shift then the table comes and we put values of x and corresponding values of y comes and we draw the graph.
- **L6**: They encourage us to use a scale on the Cartesian scale
- **L7**: Sometimes we use the graph paper.
- **L8**: They give us the first step, we find y-intercept and x-intercept, and use the turning point, we substitute x to the equation and find the value of y and then draw the graph.
- **L9**: They just give us equations so that we can work them out, get coordinates and plot the graph, in graph paper or any paper, and we check the effects of the graph.
- **L10**: They tell us how to draw the graph and they give us the formula of the graph
- **L11**: They give us the value of x, and tell us to find y using that formula.
L12-L30: Agree with the L3’s response.

The learners’ responses to question 1 show that learners were not in agreement in terms of a specific method used to teach them graphs in Mathematics. Learners pointed out that the table method is used. The other learners talked about the use of a plain paper, calculator and the use of intercepts. Other learners indicated that teachers give them the function and values of x and the learners then calculate the corresponding values for y and then plot the graph. Some of the learners indicated that teachers showed them how to draw the graph. This is supported by Raines and Clarke (2011) who argue in favor of the use of computers over traditional methods of teaching Mathematics when they insist that learners are generally attracted to computers.

The response to question 1 indicates that learners were passive in the teaching and learning process. Teachers dictated the method learners used to plot graphs.

Question 2: What were your experiences in learning hyperbolic graphs using paper and pencil?

The responses to this question were:

- **L1**: The method is a bit slow and we need a curve, and points are not enough.
- **L2**: It takes time to draw the hyperbola; it is difficult to make it curve.
- **L3**: It takes a lot of time to complete the table.
- **L4**: It takes a lot of time to find the accurate scale.
- **L5**: It takes a lot of time. The extra time I spent on drawing the graph I could use it to do other things and it is difficult.
- **L5**: It is difficult if I don’t have a ruler and wait for another learner’s ruler for her to finish using it.
- **L6**: Sometimes we are asked to draw more than three graphs
- **L7**: Or sometimes we can use wrong scales
- **L8**: Sometimes we can forget to name the x and y axis.
• **L9:** It is a bit difficult and the shape is not visible, so it is difficult.

The learners’ responses to question 2 indicate that the paper and pencil method is slow, needs more points and it is difficult. Some learners indicted that sometimes they are required to draw three graphs and the paper and pencil method makes it difficult to finish in time. Learners’ responses also pointed out that sometimes the shape of the graph is not clear if points are few. Lin (2008) indicates that using Mathematics textbook often creates a dull classroom. He further adds that involving learners in hands-on computer activities will lead to learners understanding the content.

The learners’ responses to question 2 shows that learners are not comfortable with the use of the paper and pencil method. This may indicate that the use of computers could motivate learners to engage better with hyperbolic graphs.

**Question 3:** What can you say about the importance of computers (Autograph software and Heymaths software) in learning hyperbolic graphs?

The responses to this question were:

- **L1:** The computer is fast.
- **L2:** On paper when we draw some cannot use free hand and it is not beautiful.
- **L3:** It is much simpler and faster to answer questions. We are able to know more graphs, graphs that we cannot understand in class.
- **L4:** It helps us in the assignment as it will be very fast.
- **L5:** It is easy because we just click equation and ok. If we do it ourselves it takes a longer time.
- **L6:** The points come out straight unlike when we use paper and pencil.

The learners’ responses to this question show an interest in the use of computers in learning hyperbolic graphs. They claim that the computer is accurate, fast, and easy to
work with in the area of hyperbolic graphs. Learners also indicated that more properties of hyperbolic graphs were learned in a short space of time. Some learners indicated that computers can be useful in working out assignments. This is supported by Kaput (1992) who indicates that learners working with the appropriate computer software can work with more graphs in a short space of time.

The response to question 3 indicates that the use of computers can ease some of the difficulties that learners encounter in learning hyperbolic graphs, and also improve their understanding of hyperbola graphs. However, it is important to note that, the actual drawing of the graph is a necessary skill that a learner must acquire. The use of computers can help learners to explore the properties of hyperbolas.

Question 4: What were your experiences in learning hyperbolic graphs using computer software such as Autograph software or Heymaths?

The responses to this question were:

- **L1:** I learnt many things when clicking the computer, I was unable to draw hyperbola by computer.
- **L2:** There are many things. We are unable to see the points how they came about.
- **L3:** It is much easier. We are able to see how the graph shifts when we change coefficients.
- **L5:** Same as L3.
- **L6:** It was very interesting because we just had to click the equation and the graph came out.
- **L7:** Happy because I didn’t work it myself I did it by computer.
- **L8:** It is very fast.
- **L9-L30:** Responded as L3.
Learners’ responses to this question show that learners enjoyed seeing the graph come out by just clicking buttons on the computer.

Learners’ responses show that they were able to see the effects of parameters on the graph and it was also much easier to see how the graph shifted. Gebrekal (2006) supports the response of learners when she indicates that a lot of time can be allocated to analysing the graphs and a little time to making the graphs.

The responses to question 4 indicate that learners were able to see the effects of shifting the graph easily using the computers.

**Question 5: What are the advantages of using computers when learning graphs?**

The responses to this question were:

- **L1:** *We are able to finish fast.*
- **L2:** *We are able to see the graph and facts of the graph.*
- **L3:** *No need to draw the points to plot.*
- **L4:** *It is easy to draw.*
- **L5:** *We are able to see the shifting of the graph when we increase the coefficient.*
- **L6:** *I can communicate with another learner and tell him or her how I have done it.*
- **L7:** *Same as L4.*
- **L8:** *Same as L5.*

This question was asked as a follow up to question 3 in case learners misunderstood it. Learner’s responses to this question show that learners enjoy working with computers to draw graphs.
Learners maintain that they are able to finish drawing graphs fast with computers, and that there is no need to draw a table of values. It is easy to draw the graph and one can see the movement of the graph and at the same time one can help others who do not understand how to use computers. Suharwoto (2006) explains that some of the benefits of using the computer include increased accuracy and speed in data collection and graphing, real-time visualisation, interactive modelling of mathematical processes, ability to collect, compute, and analyse large volumes of data, collaboration for data collection and interpretation, and more varied presentations of results. Suharwoto supports the learners’ responses which show that learners enjoy using computers in learning graphs.

The responses to question 5 indicate that the advantages of using the computers when studying graphs include the fact that it is easier and faster to draw graphs.

**Question 6: What are the disadvantages of using computers when learning graphs?**

The responses to this question were:

- **L1:** When you use a computer you can be perfect but when you write a test you will struggle.
- **L2:** When we are working, the electricity goes.
- **L3:** We are unable to draw for ourselves as the computer makes it easy for us.
- **L4:** It can make us to become lazy, because in a test you will not be having a computer.
- **L5:** Same as L2.
- **L6:** If at home there is no computer, so it will be difficult to apply what we have learnt.
- **L7:** We don’t know the steps on how points came about.
- **L8:** If the electricity goes.
- **L9:** In the examination we won’t have computers.
• **L10:** When you use a computer you don’t know how to draw yourself, as the computer gives you the finished product.
• **L11:** When you use computers and get answers to problems but when you write exams you will not get it.
• **L12:** If I press another key instead of the correct key then I get a wrong graph.
• **L13-L30:** Same as L2.

Learners’ responses to this question indicate that when one uses computers one can be perfect but one might struggle when writing tests. Learners pointed out that one must know how to plot the graph without the aid of a computer. Learners also indicated that in tests and examinations when computers are not available, one could struggle with hyperbolic graphs. Some learners indicated that not having a computer at home can deny them the privilege of practicing at home. Pressing the wrong key could result in getting the wrong graph.

The responses to question 6 indicate that learners need to know how to draw the hyperbola graph manually as they will be expected to draw the graph in tests and examinations. Computers can also spoil learners and they can become lazy to draw graphs on their own. The responses also indicate that electricity cuts could hinder the usage of computers in the learning of graphs.

**Question 7: Mention the challenges you encounter when using computers to learn Mathematics.**

The responses to this question were:
• **L1:** Some learners don’t know how to use the computer.
• **L2:** It needs a person who knows how to use a computer. Also to press plus on the computer we need to press shift first on the keyboard.
• **L3:** If you are addicted to using a computer and if the electricity is cut off, it can be a disadvantage.
L4: Not to find the graph you are looking for. One must know the procedure of using computers.
L5: When you don’t have a computer at home to practice using it.
L6: Same as L1.
L7: Or you take hyperbola, and write parabola then you get the wrong graph.
L8: If we are given an assignment and leave it to the last minute and when we go to the lab and find no electricity.
L9: Not to find the graph you are looking for. One must know the procedure of using a computer.

Learners indicated that it could be a challenge to use a computer if one does not know how to operate a computer. A large number of learners indicated that a computer does not show the steps that one needs to follow when drawing a graph and this is a challenge. Some learners noted that trusting the computer only could be a problem if you have an assignment which is due and on that day there is no electricity.

The responses to question 8 indicate that some learners are not able to operate a computer and this could be a challenge. The other challenge is that a computer does not show the steps involved but only gives the finished product. Electricity cuts were indicated by many learners as a disadvantage to those who rely on computers only.

**Question 8: Do you have anything else to add?**

The response to this question was:
- One learner asked how he can get the autograph programme to his home computer.
- The rest of the learners indicated that they had nothing to add.
4.4 REPRESENTATION AND ANALYSIS OF THE TEACHERS’ RESPONSES TO INTERVIEW QUESTIONS

Seven teachers were interviewed in the study. Their responses to the interview questions are discussed below:

**Question 1: How are you teaching graphs in Mathematics?**

The responses to this question were:

- **T1:** *I use the table method, we give learners x values and they compute the values of y.*
- **The Learners use graph paper but even in a plain paper they can sketch the graph.*
- **T2:** *Using graph papers and pencil. Also I make use of the Heymath programme.*
- **T3:** *Manually, by point plotting. Also by using the Autograph programme.*
- **T6-T7:** *Agreed with T1.*

The teachers’ responses to this question reflect that teachers use many methods in teaching graphs. Teachers pointed out that they use the table method, graph paper and pencil, the Heymath programme and Autograph. Bagui’s (1998) argument concurs with the responses given by teachers when he indicates that computers play a major role in assisting teachers in the classroom. The response to this question shows the integration of methods in the teaching and learning of graphs. This is supported by Kim, Lee, Spector and De Meester (2013) when they indicate that in the field of education, teachers are concerned with how to integrate computers into instruction to improve the quality of Mathematics instruction and also enhance learners’ performance.

The responses to question 1 indicate that teachers use both paper and pencil method and computers to teach graphs.
Question 2: What were your experiences in teaching hyperbolic graphs using paper and pencil?

The responses to this question were:

- T2: The shape of the graph is not clear; it depends on how accurate you are. Shapes are not clear if the Cartesian plane is not properly done and the learners miss it. It is another point where learners confuse the effects of a negative sign and when they plot some points they get lost.
- T3: It takes time; It is time consuming.
- T4: Same as T3. A lot of errors are involved.
- T5: Same as T3.
- T6: It takes time to make the table. Mostly when learners make mistakes in computing, it is difficult for them to trace their mistakes after drawing the graph. There is lack of accuracy in sketches that is smoothness of curves.
- T7: Same as T3.

The teachers’ responses to this question indicate that the shape of the graph is not clear, the method is time-consuming and the graph is not accurate. The responses to question 2 indicate that the shape of the graph is not clear when using the paper and pencil method. The paper and pencil method is also time-consuming.

Question 3: What can you say about the importance of computers (Autograph or Heymath) software in teaching hyperbolic graphs?

The responses to this question were:

- T1: One thing for sure, it is amusing; just entering an equation, the graph comes out very fast.
- T2: Learners experience more. Learners can work individually.
• **T3:** It is time saving. Heymath can be followed since there is audio. It is motivating because the voice prompts.
• **T5:** It is time-saving and accurate.
• **T6:** It is very important especially in this area of technology.
• **T7:** It is user friendly.

Teachers show interest in the use of computers to teach hyperbolic graphs. The teachers pointed out that computers are amusing. They further argue that the knowledge acquired is not conceptual but procedural. Teachers also indicated that it is time-saving to use computers in teaching hyperbolic graphs and that computers are user-friendly. Yushau, Mji and Wessels (2003) indicate that working with appropriate computer software can result in a large amount of graphing learning being experienced in a relatively short space of time. Learners acquire procedural knowledge and not conceptual knowledge.

The responses to question 3 indicate that using computers to teach hyperbolic graphs motivates learners. It is also time-saving and learners get more experience in learning graphs.

**Question 4: What were your experiences in teaching hyperbolic graphs using computer software such as Autograph or Heymath?**

The responses to this question were:

• **T2:** From past experiences we are blessed to have computers and it is possible to have learners in a computer lab. It enables us to reduce the coverage of work. Our task is just to make learners distinguish between hyperbola, parabola and trigonometric graphs.
• **T3:** It was exciting. Learners could see shifting of the graphs.
• **T4:** It is time-saving; learners enjoy using the computers. It is less of errors.
Teachers’ responses to this question indicated that they felt blessed to have computers and to teach Mathematics to learners in a computer laboratory. Teachers added that their work could be covered quicker with the aid of computers. Computers enabled learners to enjoy learning. Teachers further indicated that their role is to specify the graph learners are to study so that the computer would give them the desired graph. Yushau, Mji and Wessels (2003) support the teachers’ responses when they indicate that computers, especially in the area of graphs, can be an accurate tool of drawing the graphs.

The responses to question 4 indicate that computers enable teachers to be faster, and to cover a lot of work in a short space of time. Computers also make learning exciting for learners.

Questions 5: What are the advantages of using computers when teaching graphs?

The responses to this question were:

- **T1**: Very fast, takes shorter time.
- **T3**: It can show different graphs in a short space of time.
- **T4**: It is motivating and time saving. Learners concentrate more.
- **T5**: It is time saving and accurate
- **T6**: There are no mistakes and learners get accurate graphs faster.
- **T7**: It is simple and easy.

The teachers’ responses to this question indicated that computers motivate learners and are very fast. They also enable the teaching and learning of graphs to take shorter
time. Teachers also confirmed that different graphs can be shown in a short space of
time when using computers. According to Challoo and Marshall (2005), the majority of
teachers believed that computer technology does enhance the learners understanding
of course content.

The responses to question 5 indicate that computers are very fast, and that it takes
learners a shorter time to draw graphs.

**Question 6: What are the disadvantages of using computers when teaching
graphs?**

The responses to this question were:

- **T1:** Learners will simply come to the lab and find graphs without knowing them.
- **T2:** Internet abuse.
- **T3:** Not all the steps are done or shown. Learners tend to become lazy.
- **T4:** Learners miss the 1st principles needed in how to plot points. Learners
eventually become lazy as everything is done for them.
- **T5:** Encourages laziness to think and computers are not allowed in tests and
examinations.
- **T6:** Promotes laziness and learners do not really get to understand how the
graph came about.
- **T7:** Some learners are not exposed and overcrowded classes.

Teachers’ responses to this question show that overdependence on computers by
learners could lead to laziness. Teachers also stated that the other disadvantage of
using computers is internet abuse. Teachers also added that all the steps are not
shown when using computers, and learners tend to be lazy. Teachers also pointed out
that in examinations and tests, computers are not helpful as they are not used in the
exam room. Teachers also mentioned that over crowdedness in classes can result in
learners not being exposed to computers. The response to this question implies that
skills in teaching graphs should not be sacrificed by using the computer. This is also supported in literature by Thomas, Bosley, Delos Santos, Gray, Hong and Loh (2006) who indicate that teaching concepts without sacrificing skills is an important way of using computers.

The responses to question 6 indicate that learners could become too lazy to draw graphs on their own and this could be a major disadvantage. Computers also do not show the steps of drawing the graph, but give the finished product.

**Question 7: Mention the challenges you encounter when using computers to teach mathematics.**

The responses to this question were:

- **T1:** *Electricity can interfere with the lesson when it goes. Learners need to be empowered with computer Literacy, so they need to have such lessons before they come to the lab. Teachers need to be trained on computer usage as this is an area of challenge.*
- **T3:** *We cannot work if there is no electricity. Computers are not enough for all learners.*
- **T4:** *Using the Heymath programme we have limited examples.*
- **T5:** *Over crowdedness and limited computers.*
- **T6:** *Some classes are too big and with the limited amount of time, not all learners may get the chance to use the computer.*
- **T7:** *Being computer illiterate.*

Teachers’ responses to this question show that computers are not enough for individual learners, and this is a challenge. Teachers further suggested that learners need to be empowered with computer skills before they can make use of computers in their learning. Teachers indicated that they also needed training on computer usage as it is a major challenge. Some teachers mentioned electricity cuts off as a challenge in using
computers to teach Mathematics, and also the fact that computers are not enough for all learners.

The responses to question 7 indicate that teachers need to be trained to use many programmes that they have to teach Mathematics.

Teachers were excited that they are using computers to teach hyperbolic graphs. The teachers urged the department of education to train teachers on programmes they give to schools, in order for teachers to implement them in the teaching and learning of Mathematics.
Teachers indicated the need to be trained on the programmes the department supplies to schools.

4.5 SUMMARY OF THE DATA

This section provides a summary of the data derived from the learners’ questionnaire, learners’ interviews and teachers’ interviews. The summary draws an overall picture of what has emerged from the data with regards to the problem being investigated.

4.5.1 Summary of the Data from Learners

The aim of the investigation was to investigate the use of computers in the teaching and learning of hyperbolic graphs in grades 10 to 12 of Mathematics classes. The questionnaires were administered to learners. The analysis of the questionnaire data indicates that the use of computers can positively influence learners’ understanding of graphs in terms of problem-solving, their motivation to be involved and perception towards graphs, as well as facilitating group work and discussions among themselves.

The responses to the questions in the interview confirmed that the use of computers can positively influence learners’ understanding of graphs in terms of problem-solving,
motivation, perception and the classroom environment. The use of computers can, therefore, ease some of the difficulties that learners are facing in learning hyperbolic graphs. It can also help learners to engage with and explore the nature and properties of hyperbolic graphs. Computers can also facilitate and encourage learners to have a positive attitude towards Mathematics in general.

4.5.2 Summary of the Data from the Teachers

The responses to the questions in the interview for teachers confirmed that the use of computers can positively influence teachers’ method of teaching graphs in terms of problem-solving, motivation, perception and the classroom environment. The use of computers can, therefore, ease some of the difficulties that teachers are facing in teaching hyperbolic graphs. It can also help learners to engage with and explore the nature and properties of hyperbolic graphs. Computers can also facilitate and encourage teachers to have a positive attitude towards Mathematics in general.

However, the use of computer software programmes such as the Autograph or Heymath can have some limitations in the learning of hyperbolic graphs as one of the respondents pointed out during interview that the computer does not show the steps involved in drawing the graph.

4.6 FINAL REMARKS

Having analysed the data and seen what has emerged from the results, I will now discuss the implications of these results, the impact of the study, and then make recommendations for future studies. The chapter that follows discusses all these aspects.
CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

The purpose of this study was to investigate the use of computers in the teaching and learning of hyperbolic graphs in grades 10-12 of the Mathematics.

The study sought to address the following questions:

- What views do learners have about the use of computers to learn hyperbolic graphs in Mathematics?
- What views do teachers have about the use of computers to teach hyperbolic graphs in Mathematics?

The study followed an exploratory design as I was interested in determining how computers are used in the teaching and learning of hyperbolic graphs.

Nine secondary schools in Vhembe District, which use computers in the teaching and learning of Mathematics, took part in the study. The focus was on grades 10-12 Mathematics learners and teachers who use computers in the teaching and learning of hyperbolic graphs.

Questionnaires were distributed to a sample of 135 learners. All the questionnaires distributed were returned. The questionnaires were made available in English which is the medium of instruction at all the targeted schools.
5.2 DISCUSSION OF THE RESULTS

Based on the research question which sought to find out the view of learners about the use of computers in learning Mathematics, this study shows that learners strongly support the use of computers to learn Mathematics.

The analysis of the questionnaire data indicates that the use of computers can positively influence learners’ understanding of hyperbolic graphs, and this is indicated by the high percentage of learners (100%) who agreed that the topic of hyperbolic graphs is interesting to learn using computers. A significantly large percentage of learners (99.7%) found computers convenient to solve hyperbolic graphs. The study revealed that the majority of learners found computers helpful in drawing graphs quickly (Alper, 2009).

The need to use computers in learning Mathematics, as evident in this study, strengthens the argument presented in section 2.2 which mentions that learners favour learning Mathematics with computers more than direct instruction. What seems to emerge from these findings is that learners want to be active and not passive in the classroom. According to Raines and Clarke (2011), computers seemingly enable learners to participate fully in class.

What also was concluded from the study is that a significant percentage of learners (89.5%) found computers helpful in enabling them to get sufficient time to investigate the nature and properties of graphs. Perhaps it is for this reason that Raines and Clarke (2011) argue that learners working with appropriate software can work with more graphs in a short space of time. The hyperbolic graphs seem to take much of the learners’ time if the computing and drawing of the graph is manual. The implication of this is that computers seem to be helpful in drawing hyperbolic graphs quicker. This then results in learners getting sufficient time to investigate the nature and properties of graphs.
The responses of learners to the questions in the interview showed that the use of computers can positively influence learners’ understanding of hyperbolic graphs in terms of problem solving, motivation, perception and the classroom environment. The use of computers can, therefore, ease some of the difficulties that learners face in learning hyperbolic function. It can also enable learners to engage with and explore the nature and properties of hyperbolic graphs. Computers can also facilitate and encourage learners to have a positive attitude towards Mathematics in general. Computers enable learners to plot more graphs in a short space of time. This is confirmed in section 2.4 by Raines and Clarke (2011) under the benefits of learning Mathematics with computers which shows that computers enable learners to draw graphs much easier, quicker and more accurately. This then enables learners to devote more time to analysing the graphs.

The answer to the research question which sought to find out the views of teachers about the use of computers to teach Mathematics reveals that teachers strongly support the aid of computers in the teaching of Mathematics as indicated by Thomas, Bosley, Delos Santos, Gray, Hong and Loh (2006).

The responses of teachers to the interview questions confirmed that the use of computers can positively influence teachers’ understanding of graphs in terms of problem-solving, motivation, perception and the classroom environment. The use of computers can, therefore, ease some of the difficulties that teachers face in the teaching of hyperbolic graphs. It can also help learners to engage with and explore the nature and properties of hyperbolic graphs. Computers can also facilitate and encourage teachers to have a positive attitude towards Mathematics in general. Teachers generally complain about finishing the syllabus in time. Computers seem to be a resource that could be helpful as the preparation of lengthy calculation problems and the plotting of graphs could be achieved quicker by the computer as stated by Raines and Clarke (2011).
This is confirmed in section 2.5 under the effectiveness of teaching Mathematics with computers. The conclusion one makes from teachers’ responses to interviews is that they have a target to complete the syllabus in time. Computers can indeed be essential teaching resources and can thus be very helpful in the teaching and learning of hyperbolic graphs.

Many advantages of using computers to teach and learn Mathematics were revealed in this study such as:

- they are quick and accurate in drawing hyperbolic graphs;
- they enable learners to be active in Mathematics classrooms;
- visualization barrier is eliminated as the drawing can be enlarged to suite the learners needs;
- teachers will be able to finish the syllabus in time as lengthy preparations will be overcomed; etc.

The advantages cited above concur with the Literature cited in this study. The use of computers in learning hyperbolic graphs was supported by much of the literature cited. Raines and Clarke (2011) argue that, computers enable learners to draw graphs much easier, quicker and more accurately. Thomas, Bosley, Delos Santos, Gray, Hong and Loh (2006) also supports that, teachers prefer using computers, as they are helpful and reduce the load of making lengthy lesson preparations. Yushau, Mji and Wessels (2003) confirm that, with computers, learners can visualise mathematical concepts which are difficult to comprehend without computers. They further allude that, computers provide easier and clearer illustrations than those teachers could make.

The response of learners in interviews in this study confirms that using computers is quicker when one wants to draw graphs. This enables learners to have enough time to investigate important properties of graphs. This supports the argument presented in
section 2.5 where Moila (2006) discussed the benefits of using computers to teach and learn Mathematics.

The study shows that the disadvantage of using computers in the teaching and learning Mathematics is supported by fewer learners and teachers. This is supported by Persson (2011) when he insists that teachers mentioned risks of depending on computers in studying graphs.

There were learners who argued that computers are not useful in learning hyperbolic graphs. Few of the teachers who were interviewed also indicated that computers, even though useful, can make learners lazy. Some learners indicated that computers jump some steps in the plotting of a graph, and only produce a finished product. This is confirmed in section 2.3 were it is argued that teaching a computer intensive class can produce learners who are proficient in computer usage without grasping mathematical concepts.

Based on the research question on how computers are used in the teaching and learning of Mathematics, this study shows that a significantly large percentage of learners (90.2%) agree that computers enable them to share views with their peers, encourage them to work in groups and motivates them to work independently. The study also shows that computers enable learners to work on real life problems. Real life problems require creativity on the part of learners. In section 2.5, Yushau, Mji and Wessels (2003) argue that computers promote creativity in learners. One concludes that learners who are exposed to computers have the advantage of being skilled and creative problem solvers in Mathematics.

Learners are exposed to computers at home and in schools. Classrooms where computers are used in the teaching and learning of Mathematics help reduce the issue of visualization. This is the reason why Suharwoto (2006) argues that the benefits of
using computers include increased accuracy and speed in data collection and graphing as well as real time visualisation as indicated in section 2.5.

Findings in this study support the use of computers as a useful resource in learning Mathematics. The findings in this study are confirmed by Rowlett (2013), when he agrees that computers when placed in proper context can be useful in aiding learners to understand Mathematics. Teachers also support the use of computers in teaching hyperbolic graphs. Perhaps that is the reason why Clarke (2011), indicates that, working with appropriate computer software can pack a large amount of graphing experience into a relatively short space of time. He further states that, computers address the time factor in teaching Mathematics, enabling teachers to finish the syllabus in time. This confirms that teachers support the use of computers in teaching hyperbolic graphs as revealed in this study.

However, it is important to note that learners must know how to plot graphs manually since in the tests and examinations they plot graphs manually.

5.3 IMPLICATIONS OF THE FINDINGS

Learners’ responses to the questionnaires and the interviews showed that the use of computers can positively influence learners’ learning of graphs in terms of problem-solving. More specific, the use of computers can:

- Allow learners to draw graphs quickly and easily;
- Encourage learners to engage with and explore the nature and properties of hyperbolic graphs actively;
- Motivate learners to learn Mathematics, and enable them to be skilled and creative problem solvers, that is computers, aid learners in conceptual understanding;
- Create a positive attitude in learners towards hyperbolic graphs and Mathematics in general and give learners conceptual understanding of hyperbolic graphs.
- Encourage learners to work in groups;
• Help learners to develop self-regulation; and
• Encourage learners to interact among themselves and with their teachers.

Teachers’ responses to the interviews showed that the use of computers can positively influence teachers’ teaching of graphs in terms of problem solving. More specific, the use of computers can:
• Allow teachers to draw graphs quickly and easily;
• Encourage teachers to engage learners and explore the nature and properties of hyperbolic graphs actively;
• Motivate teachers to teach Mathematics;
• Create a positive attitude in teachers towards hyperbolic graphs and towards Mathematics in general;
• Encourage teachers to help learners to work in groups;
• Encourage teachers to help learners to develop self-regulation; and
• Encourage learners to interact among themselves and with their teachers.

### 5.4 CONCLUSION

The aim of the study was to investigate the use of computers in the teaching and learning of hyperbolic graphs in grades 10-12 Mathematics. The results of the investigation indicate that the use of computers has a positive impact on learners’ achievements, problem-solving skills or exploration of mathematical ideas, motivation, attitude and the classroom environment. This is similar to the findings reported in the literature review. Learners can analyse graphs quickly, represent graphs in different ways and solve real life problems using computers. Learners can be encouraged to explore the nature and properties of graphs on their own, work in a group, discuss concepts, make conjectures and verify their findings using computers. Thus computers can encourage learners to be active in the Mathematics classroom than they are in the traditional paper-pencil way of teaching Mathematics.
On one hand the use of computers can be helpful to teachers as it enables them to finish the syllabus efficiently. On the other hand, it serves as a learners’ resource in their learning of Mathematics.

The problem of visualisation is also overcome as each learner will have his/her own computer to work with. The issue of accuracy in graphs is also taken care of when computers are used.

Learners are by nature active. This method of employing computers makes the learners to be active in Mathematics classrooms. Teachers also benefit in the sense that preparation of materials will not take a lot of time as the computer is a complete package of resource. The role of the teacher as a facilitator is also enhanced.

5.5 LIMITATIONS OF THE STUDY

The results from this study, that, computers are useful in teaching and learning hyperbolic graphs cannot be generalised, as the study was conducted in a unique research site with specific conditions. What came out from the study may not necessarily be found in other areas.

5.6 RECOMMENDATIONS

It is recommended that:

- Computers should be used to teach all topics in Mathematics;
- School Mathematics curriculum designers and teachers should take advantage of the benefits of using computers in the teaching and learning of Mathematics, and they should encourage teaching and learning with computers;
- Teachers need training on how to use the software they have in schools so that they can make use of them fruitfully; and
• The Department of Education should purchase computers for schools without computers so that learners can make use of them in Mathematics classes. Other researchers could investigate Mathematics topics where computers can be used as a resource for teaching and learning.
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APPENDICES

Appendix A
Learners’ Questionnaire

The purpose of the questionnaire is to investigate how computers can be used to teach and learn hyperbolic graphs in Grades 10-12 Mathematics.

Personal information of learner

Please provide the following details below

School Name
Learner’s grade
Learner’s age
Learner’s sex
Do you have a computer at home? Yes or No
If yes, is the computer connected to the internet?
Do you use your computer at home for your schoolwork? Yes or No
If yes, please explain what type of school work?
**Instructions:**
- Answer all questions.
- All answers will be treated in the strictest confidence.
- Tick your choice from the given alternatives (indicate the extent to which you agree or disagree with the following).

Hyperbolic graph is an interesting topic to learn using a computer (Autograph, and Heymath etc.)

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It is convenient to solve a hyperbola graph problem using a computer software (Autograph or Heymath)

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The use of a computer (Autograph or Heymath) in learning hyperbolic graphs enables one to create tables of values of the graphs quickly.

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The use of computers in learning hyperbolic graphs enables one to draw graphs easily.

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The use of computers in learning hyperbolic graphs enables one to get sufficient time to investigate the nature and properties of the graphs.

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The use of computers in learning hyperbolic graphs gives learners the opportunity to work in groups.

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The use of computers in learning hyperbolic graphs gives learners the opportunity to share views among themselves.

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The use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their teachers.

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The use of computers in learning hyperbolic graphs motivates learners to work independently on their problems.

| Strongly disagree |   |
| Disagree         |   |
| Agree            |   |
| Strongly agree   |   |

The use of computers in learning hyperbolic graphs gives learners the opportunity to engage with real life mathematical problems.

| Strongly disagree |   |
| Disagree         |   |
| Agree            |   |
| Strongly agree   |   |
Appendix B
Interview Questions for Learners

1. How are you being taught graphs in Mathematics?
2. What were your experiences in learning hyperbolic graphs using paper and pencil?
3. What can you say about the importance of computers (Autograph software and Heymath software or any other software) in learning hyperbolic graphs?
4. What were your experiences in learning hyperbolic graphs using computer software such as Autograph and Heymath?
5. What are the advantages of using computers when learning graphs?
6. What are the disadvantages of using computers when learning graphs?
7. Mention the challenges you encounter when using computers to learn Mathematics.
8. Do you have anything else to add?

Thank you for participating in both interview and questionnaire.
Appendix C
Interview Questions for Teachers

1. How do you teach graphs in Mathematics?
2. What were your experiences in teaching hyperbolic graphs using paper and pencil?
3. What can you say about the importance of computers (Autograph or Heymath software) in teaching hyperbolic graphs?
4. What were your experiences in teaching hyperbolic graphs using computer software such as Autograph or Heymath software?
5. What are the advantages of using computers when teaching graphs?
6. What are the disadvantages of using computers when teaching graphs?
7. Mention the challenges you encountered when using computers to teach Mathematics.
8. Do you have anything else to add?

Thanking you for participating in both interview and questionnaire.
Appendix D

Transcription of Learners’ responses to interviews in pilot study

1. How are you being taught graphs in Mathematics?
   - **L1:** We use the table method using a graph paper.
   - L2: We also use plain paper to draw the graph.
   - L3: We use a calculator and press mode and shift and get a table and put values and plot the graph.
   - L4: We use the table method where we complete the table. Given the x-value and we find the y-value.
   - L5: Our teacher encourages us to find the intercepts and then plot the graph.
   - L6-L9: Same response as L1.

2. What were your experiences in learning hyperbolic graphs using paper and pencil method?
   - L1: Plotting the hyperbola graph becomes slow and the points are not enough and you can extrapolate.
   - L2: It takes time to draw a hyperbola graph and it’s difficult to turn it.
   - L3: It needs a lot of points to plot the hyperbola.
   - L4: It is quite difficult to produce a shape and it takes a lot of time to complete the table.
   - L5: Finding the accurate scale is difficult.
   - L6-L9: Same as L3’s response.

3. What can you say about the importance of computers (Autograph software and Heymaths software or any other software) in learning hyperbolic graphs?
   - L1: It is fast and takes no time to produce the graph.
   - L2: It is fast and easy.
   - L3: It gives an accurate shape and saves time.
   - L4: It is always correct
• L5: One can learn many properties of graphs within a short space of time.
• L6-L9: Same as L1’s response.

4. What were your experiences in learning hyperbolic graphs using computer software such as Autograph software or Heymaths?
• L1: We were able to see the effects of parameters on the graph
• L2: It is much easier seeing how the graph shifts.
• L3-L9: Agree with L1 and L2.

5. What are the advantages of using computers when learning graphs?
• L1: It is quick to finish drawing the graph.
• L2: You can see the graph and effects on the graph.
• L3: No need to draw table of values to plot the graph.
• L4: It is easy to draw with the computer.
• L5: Same as L2.
• L6: You can also help others who do not understand.
• L7: You can also see the movement of the graph.
• L8-L9: Agree with L4.

6. What are the disadvantages of using computers when learning graphs?
• L1: It is easy with computers but you must know how to plot the graph yourself.
• L2: The computer is not available when we write tests and examinations
• L3: When there is no electricity we cannot use computers.
• L4: You can be lazy when you depend entirely on computers to draw graphs.
• L5: When you don’t have a computer at home it could be a problem.
• L6-L9: Agree with L2 and L3.
7. Mention the challenges you encounter when using computers to learn Mathematics.
   - *L1:* There are those who do not know how to operate a computer.
   - *L2:* The computer does not show us the steps but the graph is just drawn for us.

8. Do you have anything else to add?
   - *All the learners indicated they had nothing to add.*
Appendix E

Representation and analysis of the teacher’s interviews in pilot study

1. How are you teaching graphs in Mathematics?
   - T1: *I use table method, we give learners x values and they compute the values of y.*
   - *The Learners use graph paper but even in a plain paper they can sketch the graph.*
   - T2: *Using graph papers and pencil. Also I make use of heymath program.*
   - T3: *Manually by point plotting. Also by using autograph program.*

   The responses to question 1 indicate that teachers use both paper and pencil method and computers to teach graphs.

2. What were your experiences in teaching hyperbolic graphs using paper and pencil?
   - T2: *The shape of the graph is not clear, it depends on how accurate you are. Shapes are not clear if the Cartesian plane is not properly done and the learners miss it. It is another point where learners confuse the effects of a negative sign and when they plot some points get lost.*
   - T3: *It takes time that is it is time consuming.*
   - T1: *Same as T2 and T3.*

   The responses to question 2 indicate that the shape of the graph is not clear when using the paper and pencil method. The paper and pencil method is also time consuming.
3. What can you say about the importance of computers (Autograph or Heymath software) in teaching hyperbolic graphs?

- **T1:** One thing for sure it is amusing, just entering an equation, the graph comes out very fast.
- **T2:** Learners experience more. Learners can work individually.
  - **T3:** It is time saving. Heymath can be followed since there is audio. It is motivating because the voice prompts the learners.

The responses to question 3 indicate that using computers to teach hyperbolic functions motivates learners. It is also time saving and learners experience more.

4. What were your experiences in teaching hyperbolic graphs using computers using (MS Excel, Autograph or Heymath software?)

- **T2:** From past experiences we are blessed to have computers and it is possible to have learners in a computer laboratory. It enables us to reduce the coverage of work. Our task is just to make learners distinguish between hyperbola, parabola and trigonometric graphs.
- **T3:** It was exciting. Learners could see shifting.
- **T1:** Agree with T2 and T3.

The responses to question 4 indicate that computers enable teachers to be faster and able to cover a lot of work in a short space of time. Computers also make learning exciting for learners.

5. What are the advantages of using computer when teaching graphs?

- **T1:** Very fast, takes shorter time.
- **T3:** It can show different graphs in a short space of time.
- **T2:** Same as T1.
The responses to question 5 indicate that computers are very fast and take shorter time to draw graphs.

6. What are the disadvantages of using computers when teaching graphs?
   - \textit{T1: Learners will simply come to the laboratory and find graphs without knowing them.}
   - \textit{T2: Internet abuse}
   - \textit{T3: Not all the steps are done or shown. Learners tend to become lazy.}

The responses to question 6 indicate that learners could be lazy to draw graphs on their own and this could be a disadvantage of using computers. Computers also do not show the steps of drawing the graph but gives the finished product.

7. Mention the challenges you encounter when using computers to teach Mathematics.
   - \textit{T1: Electricity can interrupt the lesson when it goes off. Learners need to be empowered with computer Literacy, so they need to have such lessons before they come to the laboratory. Educators need to be trained on computer usage as this is an area of challenge.}
   - \textit{T3: We cannot work if there is no electricity. Computers are not enough for all the learners.}
   - \textit{T2: Same as T1 and T3.}

The responses to question 7 indicate the challenge on the need to train teachers to use many programmes that they have in studying mathematics.

8. Do you have anything else to add?
   - \textit{T1: We now know Autograph that was with us for a long time and we knew very little about it. Now we can make use of it.}
• T2: The department must train educators on the programme they give to schools in order for educators to implement in the teaching and learning of mathematics.

Teachers indicated the need to train educators on the programmes they supply to schools.
Appendix F

Transcription of interview responses of Learners who use computers at home

Question

Do you use your computer at home for your school work? If yes, please explain what type of work you do with your computers.

• L1: It helps me to do research using the student library for my investigation and research tasks. I use my computer to type my CV.
• L2: Learn more about Microsoft office programs.
• L3: I use the computer to do practical investigations
• L4: Investigations and researches.
• L5: If I am given a research project and investigation, I can use the internet to find some information that can help me to do my investigation or my research. I Google.
• L6: I use my laptop to connect internet the internet then I Google information that I want. I use Google in the internet to search for information.
• L7: Life Sciences, Life orientation and Physical Sciences assignment and investigations.
• L8: Collecting data on the internet when information in books is not enough as in the case when talking about the world of today and statistics.
• L9: Downloading some of question papers and treat them. Investigating something I don’t know which is relative to schoolwork
• L10: I use it when searching for things or information needed at school e.g. Life Sciences, Geography, Life orientation only.
• L11: Searching for programmes which are needed. For example in Geography we learn about G/S (Geographicinternation system)
• L12: I take my economics notes from my teacher via my USB and I open my notes on the pc and print them if I want. I study better with notes on the pc than when they are in my books.
• L13: I use my computer for my Mathematics. If I have not found my calculator and I also use it for other subjects if I have projects, investigations and researches.

• L14: I write Mathematics, English and Science and it is quicker and easier.

• L15: The computer I use at home is a personal computer that has internet and its fast in finding information (it’s a desktop computer).

• L16: Typing assignments and knowing the correct spelling of each word.

• L17: Researching all homework and projects.

• L18: Looking for assignments.

• L19: Same as L18’s response.

• L20: I cannot use it all the time but I have it.

• L21: I use it to listen to music and watch movies, and sometimes access the internet.

• L22: Because it doesn’t have the programmes of what we are learning at school.

• L23: I use the computer for my school work when I am doing research for something that is related to my school work. In order to find more information about my research.

• L24: Writing tasks and finding information through internet.

• L25: I type my projects since I do computer application technology at school and I do my computer practical using my computer at home to do school tasks.

• L26: I mostly use my computer to guide me along the university disk view e.g. like the university of Tshwane which helps me to learn more about the situation at the university and it teaches me some courses.

• L27: I do computer application technology at school, so I go home and study it and do some homework and assignments.

• L28: Same as L16’s response

• L29: I use it to find information about a particular subject that was given to me e.g. I insert a CD which has Wikipedia and that is where I get the information I want
• **L30:** I use my personal pc to try and study how to draw some of the mathematical graphs.

• **L31-33:** They were silent, that is they gave me no responses but indicated they had computers at home.
Appendix G

Transcription of Learners’ responses to interviews questions in the main study

1. How are you being taught graphs in Mathematics?
   • L1: Most of the time she starts by telling us the function, tells us to press the mode and then the table will appear and then we draw the graph.
   • L2: When she is teaching us she will tell us the values of x and we find y and then draw the graph.
   • L3: They use the table method, where you have to complete the table, given x and you find y.
   • L4: We use a calculator, when we press shift it will make us a table and we use the table, then we will choose the table they will ask us where the graph starts and end and we will plot the graph.
   • L5: We press mode and then shift then the table comes and we put values of x and the corresponding values of y come up and we draw the graph.
   • L6: They encourage us to use a scale on the Cartesian scale
   • L7: Sometimes we use graph paper.
   • L8: They give us the first step, we find y-intercept and x-intercept, and use the turning point, we substitute x to the equation and find the value of y and then draw the graph.
   • L9: They just give us equations so that we can work them out, get coordinates and plot the graph, on graph paper or any paper, and we check effects of the graph.
   • L10: They tell us how to draw the graph and they give us the formula of the graph
   • L11: They give us the value of x, and tell us to find y using that formula.
   • L12-L30: Agree with L3’s response
2. What were your experiences in learning hyperbolic graphs using paper and pencil?

- **L1**: The method is bit slow and we need a curve and points are not enough.
- **L2**: It takes time to draw the hyperbola; it is difficult to make it curve.
- **L3**: It takes a lot of time to complete the table.
- **L4**: It takes a lot of time to find the accurate scale.
- **L5**: It takes a lot of time. The more time I spent on drawing the graph I could use it to do other things and it is difficult.
- **L5**: It is difficult if I don’t have a ruler and wait for another learner's ruler for her to finish using it.
- **L6**: Sometimes we are asked to draw more than three graphs
- **L7**: Or sometimes we can use wrong scales
- **L8**: Sometimes we can forget to name the x and y axis.
- **L9**: It is a bit difficult and the shape is not visible, so it is difficult.

3. What can you say about the importance of computers (Autograph software and Heymaths software or any other software) in learning hyperbolic graphs?

- **L1**: The computer is fast.
- **L2**: On paper when we draw some cannot use free hand and it is not beautiful.
- **L3**: It is much simpler and faster to answer questions. We are able to know more graphs, that we cannot understand them in the class.
- **L4**: It helps us in the assignment as it will be very fast.
- **L5**: It is easy because we just click equation and ok if we do it ourselves it takes a longer time.
- **L6**: The points come out straight unlike the paper and pencil.

4. What were your experiences in learning hyperbolic graphs using computer software such as Autograph software or Heymaths?

- **L1**: I learnt many things when clicking the computer, I was unable to draw hyperbola by computer.
• L2: There are many things. We are unable to see the points how they came about.
• L3: It is much easier. We are able to see how the graph shifts when we change coefficients.
• L5: Same as L3.
• L6: It was very interesting because we just had to click the equation and the graph came out
• L7: Happy because I didn’t work it myself I did it by computer.
• L8: It is very fast.
• L9-L30: Same response as L3.

5. What are the advantages of using computers when learning graphs?
• L1: We are able to finish fast.
• L2: We are able to see the graph and facts of the graph.
• L3: No need to draw the of points to plot.
• L4: It is easy to draw.
• L5: We are able to see the shifting of the graph when we increase the coefficient.
• L6: I can communicate with another learner and tell him or her how I have done it.
• L7: Same as L4.
• L8: Same as L5.

6. What are the disadvantages of using computers when learning graphs?
• L1: When you use a computer you can be perfect, but when you write a test you will struggle.
• L2: When we are working the electricity goes.
• L3: We are unable to draw for ourselves as the computer makes it easy for us.
• L4: It can make us to become lazy because in a test you will not be having a computer.
• L5: Same as L2.
• L6: If at home there is no computer, it will be difficult to apply what we learnt.
• L7: We don’t know the steps of how points came about.
• L8: If the electricity goes.
• L9: In the examination we won’t have computers.
• L10: When you use a computer you don’t know how to draw the graph for yourself, as computers give you the finished product.
• L11: When you use a computer and get the graph correctly but when you write exams you will not get the graph correctly.
• L12: If I press another key instead of the correct key, then I will get a wrong graph.
• L7-L30: Same as L2.

7. Mention the challenges you encounter when using computers to learn Mathematics.
• L1: Some learners don’t know how to use the computer.
• L2: It needs a person who knows how to use a computer. Also to press plus on the computer, we need to press shift first on the keyboard.
• L3: If you are addicted to using a computer and the electricity is off, it can be a disadvantage.
• L4: Not to find the graph you are looking for. One must know the procedure of using a computer.
• L5: When you don’t have a computer at home to practice using it.
• L6: Same as L1.
• L7: Or you take hyperbola, and write parabola then you get the wrong graph.
• L8: If we are given an assignment and leave it to the last minute and when you go to lab and find no electricity.
• L9: Not to find the graph you are looking for. One must know the procedure of using a computer.
8. Do you have anything else to add?

- One learner asked how he can get the autograph programme to his home computer.
- The rest of the learners indicate they have nothing to add.
Appendix H

Transcription of Teachers’ responses to interview questions

Seven teachers were interviewed:

1. How do you teach graphs in Mathematics?
   • T1: I use the table method, we give learners x values and they compute the values of y.
   • The Learners use graph paper but even on plain paper, they can sketch the graph.
   • T2: Using graph papers and pencil. Also I make use of the Heymath programme.
   • T3: Manually by point plotting. Also by using the Autograph programme.
   • T6-T7: Agreed with T1.

2. What were your experiences in teaching hyperbolic graphs using the paper and pencil?
   • T2: The shape of the graph is not clear; it depends on how accurate you are. Shapes are not clear if the Cartesian plane is not properly done and the learners miss it. It is another point where learners confuse the effects of a negative sign and when they plot some points get lost.
   • T3: It takes time, that is, it is time consuming.
   • T4: Same as T3. A lot of errors are involved.
   • T5: Same as T3.
   • T6: It takes time to make the table. Mostly when learners make mistakes in computing, it is difficult for them to trace their mistakes after drawing the graph. There is lack of accuracy in sketches that is smoothness of curves.
   • T7: Same as T3.
3. What can you say about the importance of computers (Autograph or Heymath software) in teaching hyperbolic graphs?

- **T1**: One thing for sure, it is amusing. When one just enters an equation, the graph comes out very fast.
- **T2**: Learners experience more. Learners can work individually.
- **T3**: It is time-saving. Heymath can be followed since there is audio. It is motivating because of the voice prompts.
- **T5**: It is time-saving and accurate
- **T6**: It is very important, especially in this area of technology
- **T7**: It is user-friendly.

4. What were your experiences in teaching hyperbolic graphs using computer software such as Autograph or Heymath software?

- **T2**: From past experiences, I would say we are blessed to have computers and it is possible to have learners in a computer lab. It enables us to reduce the coverage of work. Our task is just to make learners distinguish between hyperbola, parabola and trigonometric graphs.
- **T3**: It was exciting. Learners could see shifting of the graphs.
- **T4**: It is time-saving. Learners enjoy using the computers. It is less of errors.
- **T5**: It was excellent.
- **T6**: There are no mistakes and learners get accurate graphs faster.
- **T7**: It is better.

5. What are the advantages of using computers when teaching graphs?

- **T1**: Very fast, takes a shorter time.
- **T3**: It can show different graphs in a short space of time.
- **T4**: It is motivating and time-saving. Learners concentrate more.
- **T5**: It is time saving and accurate.
- **T6**: There are no mistakes and learners get accurate graphs faster.
- **T7**: It is simple and easy.
6. What are the disadvantages of using computers when teaching graphs?
   - T1: Learners will simply come to the lab and find graphs without knowing them.
   - T2: Internet abuse.
   - T3: Not all the steps are done or shown. Learners tend to become lazy.
   - T4: Learners miss the 1st principles needed in how to plot points.
   - Learners eventually become lazy as everything is done for them.
   - T5: Encourages laziness to think.
   - T6: Promotes laziness and learners do not really get to understand how the graph came about.
   - T7: Some learners are not exposed to computers and overcrowded classes.

7. Mention the challenges you encounter when using computers to teach Mathematics.
   - T1: Electricity can interfere with the lesson when it goes. Learners need to be empowered with computer Literacy, so they need to have such lessons before they come to the lab. Teachers need to be trained on computer usage as this is an area of concern.
   - T3: We cannot work if there is no electricity. Computers are not enough for all learners.
   - T4: Using the Heymath programme we have limited examples.
   - T5: Over crowdedness and limited computers.
   - T6: Some classes are too big, and with the limited amount of time, not all learners may get the chance to use the computer.
   - T7: Being computer illiterate.

8. Do you have anything else to add?
   - T1: We now know Autograph that was with us and we knew little about it. Now we can make use of it.
   - T7: Most programmes must be installed in school computers.
Appendix I

Presentation of results from the pilot study

Figure 3.1 below, shows how learners agreed or disagreed with items on the use of computers to learn hyperbolic graphs.

Fig: 3.1: The extent to which learners agreed or disagreed with items in the questionnaire.
Table 3.1: Percentage average scores of learners’ response per item

<table>
<thead>
<tr>
<th>Response</th>
<th>Item 1</th>
<th>Item 2</th>
<th>Item 3</th>
<th>Item 4</th>
<th>Item 5</th>
<th>Item 6</th>
<th>Item 7</th>
<th>Item 8</th>
<th>Item 9</th>
<th>Item 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2.9%</td>
<td>0%</td>
</tr>
<tr>
<td>Disagree</td>
<td>0%</td>
<td>0%</td>
<td>5.7%</td>
<td>2.9%</td>
<td>0%</td>
<td>8.6%</td>
<td>2.9%</td>
<td>5.7%</td>
<td>14.3%</td>
<td>0%</td>
</tr>
<tr>
<td>Disagree</td>
<td>0%</td>
<td>0%</td>
<td>5.7%</td>
<td>2.9%</td>
<td>0%</td>
<td>8.6%</td>
<td>2.9%</td>
<td>5.7%</td>
<td>14.3%</td>
<td>0%</td>
</tr>
<tr>
<td>Agree</td>
<td>48.6%</td>
<td>65.7%</td>
<td>28.6%</td>
<td>40%</td>
<td>45.7%</td>
<td>37.1%</td>
<td>42.9%</td>
<td>42.9%</td>
<td>42.9%</td>
<td>57.1%</td>
</tr>
<tr>
<td>Strongly</td>
<td>51.4%</td>
<td>34.3%</td>
<td>65.7%</td>
<td>57.1%</td>
<td>54.3%</td>
<td>54.3%</td>
<td>54.3%</td>
<td>54.3%</td>
<td>51.4%</td>
<td>40%</td>
</tr>
<tr>
<td>Agree</td>
<td>51.4%</td>
<td>34.3%</td>
<td>65.7%</td>
<td>57.1%</td>
<td>54.3%</td>
<td>54.3%</td>
<td>54.3%</td>
<td>54.3%</td>
<td>51.4%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Table 3.1: Percentage average scores of learners’ response per item

Table 3.1 above presents the percentage average scores of learners’ responses per item in the questionnaire.

Figure 3.1, above shows us that a higher percentage of learners agree that computers are useful in learning hyperbolic graphs. Only a smaller percentage of learners disagree that computers are useful in learning hyperbolic graphs.

In Table 3.1 above, all the learners (100%) agree that computers are useful in learning hyperbolic graphs. Only 2.9% of the learners disagree that computers can motivate learners to work independently.

In Figure 3.2 below, the learners’ responses have been categorised into agree or disagreed. That is, each of the positives (strongly agree and agree) were grouped together and likewise the negatives (disagree and strongly disagree). Figure 3.2 shows
how learners agreed or disagreed with items on the use of computers in the learning of hyperbolic graphs.

Fig 3.2: The extent to which learners agreed or disagreed with items in the questionnaire.
Table 3.2: Percentage average scores of learners’ responses per item

<table>
<thead>
<tr>
<th>Item 1</th>
<th>Item 2</th>
<th>Item 3</th>
<th>Item 4</th>
<th>Item 5</th>
<th>Item 6</th>
<th>Item 7</th>
<th>Item 8</th>
<th>Item 9</th>
<th>Item 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree or Disagree</td>
<td>0%</td>
<td>0%</td>
<td>5.7%</td>
<td>2.9%</td>
<td>0%</td>
<td>8.6%</td>
<td>2.9%</td>
<td>5.7%</td>
<td>17.1%</td>
</tr>
<tr>
<td>Agree or Strongly agree</td>
<td>100%</td>
<td>100%</td>
<td>94.3%</td>
<td>97.1%</td>
<td>100%</td>
<td>91.4%</td>
<td>97.1%</td>
<td>94.3%</td>
<td>82.9%</td>
</tr>
</tbody>
</table>

Table 3.2 presents the percentage average scores of learners’ responses per item in the questionnaire.

In Figure 3.2 above, a higher percentage of learners strongly agree or agree that computers are useful in learning hyperbolic graphs. Only a few learners indicated that computers are not useful in learning hyperbolic graphs.

In Table 3.2 above all the learners (100%) agree that computers are useful in learning hyperbolic graphs. 17.9% of the learners disagree that computers motivate learners to work independently.

**Representation and analysis of the data in the learner’s questionnaire of the pilot study**

The aim of the pilot test was to assess the instrument’s validity and reliability. The researcher wanted to determine whether the questionnaire items were meaningful to learners. The data obtained from the questionnaire was analysed. The analysis of the pilot data is in the next section.
Question 1: Hyperbolic graph is an interesting topic to learn using a computer (Autograph, and Heymath etc.)

All the learners, that is 100% of the learners, agree that hyperbolic function is an interesting topic to learn using computers.

Question 2: It is convenient to solve a hyperbola graph problem using a graph if you use a computer (Autograph or Heymath)

All the learners, that is 100% of the learners, agree that it is convenient to solve a hyperbola graph problem using a computer.

The responses to item 1 and 2, presented in Figure 3.2 and Table 3.2 indicate that the use of computers can encourage learners to learn hyperbolic graphs and produce a positive disposition in learners towards hyperbolic graphs. All the respondents agreed that a hyperbolic graph is an interesting topic to learn using a computer.

Question 3: The use of a computer (Autograph or Heymath) in learning hyperbolic graphs enables one to create tables of values of the graphs quickly

A small percentage, that is 5.7% of the learners, disagree that the use of computers in learning hyperbolic graphs enables one to create tables of values of the graphs quickly.

A high percentage (94.3%) of the learners agree that the use of computers in learning hyperbolic graphs enables one to create tables of values of the graphs quickly.
Question 4: The use of computers in learning hyperbolic graphs enables one to draw graphs easily.

A significantly low percentage, that is 2.9% of the learners, disagree that the use of computers in learning hyperbolic graphs enables one to draw graphs easily. A fairly high percentage that is 97.1% of the learners agrees that the use of computer in learning hyperbolic graphs enables one to draw graphs easily.

Question 5: The use of computers in learning hyperbolic graphs enables one to get sufficient time to investigate the nature and properties of the graphs

All the learners agree that the use of computers in learning hyperbolic graphs enables one to get sufficient time to investigate the nature and properties of the graphs.

Question 6: The use of computers in learning hyperbolic graphs gives learners the opportunity to work in groups

A small percentage (8.6%) of the learners disagree that the use of computers in learning hyperbolic graphs gives learners the opportunity to work in groups. The majority of the learners (91.4%) agree that the use of computers in learning hyperbolic graphs gives learners the opportunity to work in groups.

Question 7: The use of computers in learning hyperbolic graphs gives learners the opportunity to share views among themselves.

A low percentage (2.9%) of the learners disagree that the use of computers in learning hyperbolic graphs gives learners the opportunity to share views among themselves. A high percentage that is 97.1% of the learners agree that the use of computers in
learning hyperbolic graphs gives learners the opportunity to share views among themselves

**Question 8:** The use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their teachers.

A small percentage (5.7%) of the learners disagree that the use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their teachers. A high percentage that is 94.3% of the learners agree that the use of computers in learning hyperbolic graphs gives learners the opportunity to share views with their teachers.

**Question 9:** The use of computers in learning hyperbolic graphs motivates learners to work independently their problems.

A low percentage (17.1%) of the learners disagree that the use of computers in learning hyperbolic graphs motivates learners to work independently their problems. A high percentage (82.9%) of the learners agree that the use of computers in learning hyperbolic graphs motivates learners to work independently their problems.

**Question 10:** The use of computers in learning hyperbolic graphs gives learners the opportunity to engage with real life mathematical problems.

All learners agree that the use of computers in learning hyperbolic graphs gives learners the opportunity to engage with real life mathematical problems.

The responses to items 3, 4, 5, 9, and 10 as presented in Figure 3.1 and Table 3.1 and Figure 3.2 and Table 3.2 above indicate that the use of computers can enable learners to engage with and explore the nature and properties of hyperbolic functions and their graphs easily and quickly.
The responses to item 6, 7 and 8 as presented in Figure 3.1 and Table 3.1 and Figure 3.2 and Table 3.2 above indicates that the use of computers can facilitate learners’ group work and facilitate discussion among themselves and between learners and teachers.

The data gathered through the questionnaire strongly supports the argument that computers are useful in learning hyperbolic graphs. The literature review also supports the use of computers in the teaching and learning of mathematics. It is, therefore, important to integrate the use of computers into the teaching and learning of mathematics.

Learners who have computers at home and use them for mathematical school work were interviewed and their responses are analysed below. A total of nine learners were interviewed in the pilot study. These are learners who had indicated that they have computers at home and that they use them for mathematical tasks. The following section presents analysis of interview questions.

**REPRESENTATION AND ANALYSIS OF THE LEARNER’S INTERVIEWS**

1. How are you being taught graphs in mathematics?

The learners’ responses to question 1 reflect that learners were not in agreement in terms of specific methods which are used to teach them graphs in Mathematics. Six of the learners pointed out that the table method is used. The other learners talked about the use of a plain paper, calculator and the use of intercepts. The literature review points out that the traditional paper and pencil method is ineffective in teaching graphs as learners become passive in class. This is in agreement with Kehagis and Vlachos (1996) who say that learners are generally attracted to computers.
The response to question 1 indicates that learners were passive in the teaching and learning process. Teachers were the ones dictating the method learners use to plot graphs.

2. What were your experiences in learning hyperbolic graphs using paper and pencil method?
The responses of learners to question 2 indicate that the paper and pencil method is slow, needs more points and it is difficult. This is supported by Lin (2008) who argued that pre-service teachers expressed a desire to integrate the use of computers in their classroom instruction. He further indicates that using Mathematics textbooks often creates a dull classroom. Involving learners in hands-on activities which require them to use using computers as resources will help learners to understand content.
The responses of learners to question 2 show that learners are not comfortable with the use of the paper and pencil method. This may be interpreted as indicating that the use of computers could serve as a motivation for learners to draw better hyperbolic graphs.

3. What can you say about the importance of computers (Autograph software and Heymath software) in learning hyperbolic graphs?
To this question, learners showed an interest in the use of computers in learning hyperbolic graphs. They claim that the computer is accurate, fast, and easy to work with in the area of hyperbolic graphs. Learners also indicated that more properties of hyperbolic graphs were learned in a short space of time. Computers enable learners to cover more graphs than when they draw them manually. This is supported by Kaput (1992) who indicates that learners working with the appropriate computer software can work with more graphs in a short space of time.

The response to question 3 indicates that the use of computers can ease some of the difficulties that learners encounter in learning hyperbolic graphs and improve their understanding of hyperbola graphs. The use of computers can help learners to explore the properties of hyperbolas.
4. What were your experiences in learning hyperbolic graphs using computers using Autograph software or Heymaths?

Learners’ responses show that they were able to see the effects of parameters on the graph, and that it was also much easier to see how the graph shifted. Gebrekal (2006) supports the response of learners when she indicates that a lot of time can be allocated to analysing the graphs and a little time to making the graphs.

The responses to question 4 indicate that learners were able to see the effects of shifting the graph easily using computers.

5. What are the advantages of using computers when learning graphs?

This question was asked as a follow up to question 3 in case learners misunderstood it. Learners’ responses to this question show that learners enjoy working with computers in drawing graphs.

Learners maintain that computers are quick in drawing graphs, that there is no need to draw a table of values, it is easy to use computers in drawing graphs, you can see the movement of the graph and you can help others who do not understand through the use of computers. The learners’ responses are in agreement with Suharwoto (2006) who explains that the benefits of using the computer include increased accuracy and speed in data collection and graphing, real-time visualisation, interactive modelling of mathematical processes, ability to collect, compute, and analyse large volumes of data, collaboration for data collection and interpretation and more varied presentation of results.

The response to question 5 indicates that the advantages of using computers in studying graphs include the fact that it is easier and faster to draw graphs.
6. What are the disadvantages of using computers when learning graphs?
Learners’ responses to this question indicate that over dependency on computers can be problematic. Learners pointed out that one must know how to plot the graph without the aid of a computer. Many learners indicated that electricity cuts could be a disadvantage if one relies on computers only. Learners also indicated that in tests and examinations, where computers are not available, one could struggle with hyperbolic graphs. The issue of sacrificing skills was indicated by learners when they responded. They argued that computers jump all the steps of drawing a graph, and only give the finished product.

The responses to question 6 indicate that learners need to know how to draw the graph manually as they will be expected to draw the graph in tests and examinations. Computers can also spoil learners and they can become lazy to draw graphs on their own. The responses also indicate that electricity could hinder the use of computers in the learning of graphs.

7. Mention the challenges you encounter when using computers to learn mathematics
Few of the learners indicated that it could be a challenge to use a computer if one does not know how to operate a computer. A large number of learners indicated that a computer does not show the steps followed when drawing a graph, and this is a challenge.

The responses to question 8 indicate that some learners are not able to operate a computer; This could be a challenge. The other challenge is that a computer does not show the steps involved in the drawing of a graph, but only gives the finished product.

8. Do you have anything else to add?
All the learners indicated they had nothing to add.
An interview was also conducted with three teachers who taught Mathematics Grades 10 to 12 in the pilot study.

**REPRESENTATION AND ANALYSIS OF THE TEACHER’S INTERVIEWS IN PILOT STUDY**

1. How are you teaching graphs in Mathematics?
   The responses of teachers to this question reflect that teachers integrate many methods in teaching graphs. Teachers pointed out that they use the table method, graph paper and pencil, the Heymath programme and Autograph. Literature supports the use of computers in mathematics classroom. This is confirmed by Bagui (1998) when he indicates that computers are play an increasing role in assisting teachers in the classroom. The response to this question shows the integration of methods in the teaching and learning of graphs. This is supported by Mc-Donald and Trutman (2005) who indicate that in the field of education, teachers are concerned with how to integrate computers into instruction, in order to improve the quality of Mathematics instruction and also enhance learners’ performance.

   The responses to question 1 indicate that teachers use both paper and pencil method and computers to teach graphs.

2. What were your experiences in teaching hyperbolic graphs using paper and pencil?
   The responses of the teachers to this question indicate that the method is time-consuming, and the shape of the graph is not clear.

   The responses to question 2 indicate that the shape of the graph is not clear when using the paper and pencil method. The paper and pencil method is also time consuming.
3. What can you say about the importance of computers (Autograph or Heymath software) in teaching hyperbolic graphs?

Teachers showed interest in the use of computers to teach hyperbolic graphs. The teachers pointed out that computers are amusing. They further pointed out that if one just entered an equation where the graph would come out fast. Teachers also indicated that it is time saving to use computers in teaching hyperbolic graphs. Literature supports the use of computers in teaching Mathematics. According to Yushau, Mji and Wessels (2003), working with appropriate computer software can result in one packing a large amount of graphing experience into a relatively short space of time.

The responses to question 3 indicate that using computers to teach hyperbolic graphs motivates learners. It is also time saving and learners experience more.

4. What were your experiences in teaching hyperbolic graphs using computers using (Autograph or Heymath software?)

Teachers’ responses to this question indicated that they felt blessed to have computers and to be teaching learners Mathematics in a computer laboratory. Teachers reflected that their work could be covered quicker with the aid of computers. Computers enabled learners to enjoy learning. Teachers further indicated that their role is to specify the graph learners are to study so that the computer would give them the desired graph. Teachers also alluded to the fact that computers are accurate tools for drawing graphs. This is strengthened by Yushau, Mji and Wessels (2003) who indicate that computers, especially in the area of graphs, can be an accurate tool of drawing the graphs.

The responses to question 4 indicate that computers enable teachers to be faster and to cover a lot of work in a short space of time. Computers also make learning exciting for learners.
5. What are the advantages of using computers when teaching graphs?
The teachers’ responses to this question indicated that computers are very fast and take shorter time when used to teach graphs. The teachers also confirmed that different graphs can be shown using computers in a short space of time. Teachers support the use of computers in the teaching of Mathematics. According to Challoo Marshall (2005), the majority of teachers believed that computer technology does enhance the learners understanding of course content.

The responses to question 5 indicate that computers are very fast and enable one to take shorter time to draw graphs.

6. What are the disadvantages of using computers when teaching graphs?
To this question, teachers pointed out that the overdependence on computers by learners could be a disadvantage. Teachers also stated that other disadvantages in using computers include internet abuse. The teachers also added that all the steps are not shown when one is using computer and that learners tend to be lazy. The response to this question implies that skills in teaching graphs should not be sacrificed by using the computer. This is also supported in literature by Thomas, Bosley, Delos Santos, Gray, Hong & Loh (2006) who they indicate that teaching concepts without sacrificing skills is an important way of using computers.

The responses to question 6 indicate that learners can be lazy to draw graphs on their own, and this could be a disadvantage of using computers. Computers also do not show the steps of drawing the graph, but just give the finished product.

7. Mention the challenges you encounter when using computers to teach Mathematics
Teachers’ responses suggested that learners need to be empowered with computer skills before teachers can make use of computers in teaching. Teachers further indicated that they also needed training on computer usage as it is a challenging area.
Some teachers mentioned electricity cuts as also a challenge of using computers in the teaching of Mathematics. They also said that computers are not enough for all learners. Literature shows us that there is need to train teachers on how to use computers. This is supported by Smith-Gratto and Fischer (1999) who indicate that lack of appropriate teacher-training is often considered as the main problem in implementing computers in classroom instruction.

The responses to question 7 indicate the need to train teachers to use various programmes in the studying of Mathematics.

8. Do you have anything else to add?
Teachers were excited that they are using computers to teach hyperbolic graphs. They recommended that the department of education should train them on the programmes they give to schools, in order for teachers to implement them in the teaching and learning of Mathematics. Teachers indicated the need to train teachers on the programmes the department of education supplies to schools.
Appendix J
Request permission letter to the School

Enquiries: Mavhungu LE
0726009029

X Sec. School
01-08-2011

Sir

Request for permission to collect data at your school

With reference to the above matter, kindly consider my request to collect data at your school. The data is for my study in Masters of Science in Mathematics, Science and Technology degree that I am presently doing with the University of South Africa.

In this study the teachers and learners in grade 10-12 will be sampled to participate. Classroom observations will also be done when the computers are used in the teaching and learning of Mathematics.

Your cooperation is always appreciated.

Yours faithfully
Mavhungu LE
The Principal
Mphathuli Sec. School
Private Bag X2212
Sibasa
0970
18-02-2011

Sir

Request for permission to do data collection at your school

1. With reference to the above matter kindly consider my request to collect data at your school.
2. The data is for my study in Masters of Science in Mathematics, Science and technology degree that I’m presently doing with the University of South Africa.
3. In this study the educators and learners in grade 10-12 will be sampled to participate.
4. Classroom observation will also be done when the computers will be used in teaching and learning Mathematics.
5. Your cooperation is always appreciated.

Yours Faithfully
Mavhungu LE

[Signature]

[Stamp: Permission granted]

MPAPHLULI HIGH SCHOOL
DEPARTMENT OF EDUCATION

[Stamp: Principal]

2011-04-07

PRIVATE BAG X573 SIBASA 0970
TELEFAX (015) 933 1218
LIMPOPO PROVINCE
The Principal
Manelendi Sec. School
25-07-11

Sir

Request for permission to do data collection at your school

1. With reference to the above matter kindly consider my request to collect data at your school.
2. The data is for my study in Masters of Science in Mathematics, Science and technology degree that I’m presently doing with the University of South Africa.
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5. Your cooperation is always appreciated.

Yours Faithfully
Mavhungu LE

DEPARTMENT OF EDUCATION
MANELEDZI SECONDARY SCHOOL
03 SEP 2011
P.O. BOX 580 MAKHADO 0920
LIMPOPO PROVINCE

Permission granted.
Request permission letter to the School

ENQUIRIES: MAVHUNGU LE
072809029

58 Cronje Street
Makhado
0920

Lushovhu Sec. School
01-08-2011

Sir

Request for permission to do data collection at your school

1. With reference to the above matter kindly consider my request to collect data at your school.
2. The data is for my study in Masters of Science in Mathematics, Science and technology degree that I’m presently doing with the University of South Africa.
3. In this study the educators and learners in grade 10-12 will be sampled to participate.
4. Classroom observation will also be done when the computers will be used in teaching and learning Mathematics.
5. Your cooperation is always appreciated.

Yours Faithfully
Mavhungu LE

Permission has been granted.
The Principal  
Kutama Sec. School  
P.O. Box 426  
Kutama  
0940  
18-02-2011  

Sir  

Request for permission to do data collection at your school  

1. With reference to the above matter kindly consider my request to collect data at your school.  
2. The data is for my study in Masters of Science in Mathematics, Science and technology degree that I’m presently doing with the University of South Africa.  
3. In this study the educators and learners in grade 10-12 will be sampled to participate.  
4. Classroom observation will also be done when the computers will be used in teaching and learning Mathematics.  
5. Your cooperation is always appreciated.  

Yours Faithfully  
Mavhungu LE  

[Signature]

[Stamp: Permission Granted]  

[Stamp: Principal: Kutama Sec., 17/02/2011]
Request permission letter to the School

ENQUIRIES: MAVHUNGU LE
072809029

58 Cronje Street
Makhado
0920

The Principal
Azwifarwi Secondary School
01-08-2011

Sir

Request for permission to do data collection at your school

1. With reference to the above matter kindly consider my request to collect data at your school.
2. The data is for my study in Masters of Science in Mathematics, Science and technology degree that I’m presently doing with the University of South Africa.
3. In this study the educators and learners in grade 10-12 will be sampled to participate.
4. Classroom observation will also be done when the computers will be used in teaching and learning Mathematics.
5. Your cooperation is always appreciated.

Yours Faithfully
Mavhungu LE

AZWIFARWI SEC. SCHOOL
PRINCIPAL
2011-08-23
P.O. Box 2912, Thohoyandou, 0650
TEL: 015 362 2479

permission granted.
Request permission letter to the School

ENQUIRIES: MAVHUNGU LE
0728009029

58 Cronje Street
Makhado
0920

The Principal
Tshiawelo Secondary School
01-08-2011

Sir

Request for permission to do data collection at your school

1. With reference to the above matter kindly consider my request to collect data at your school.
2. The data is for my study in Masters of Science in Mathematics, Science and technology degree that I’m presently doing with the University of South Africa.
3. In this study the educators and learners in grade 10-12 will be sampled to participate.
4. Classroom observation will also be done when the computers will be used in teaching and learning Mathematics.
5. Your cooperation is always appreciated.

Yours Faithfully
Mavhungu LE

Permission granted

[Signature]
Request permission letter to the School

ENQUIRIES: MAVHUNGU LE
0725603929

58 Cronje Street
Makhado
0920

The Principal
Silemale Secondary School
01-08-2011

Sir

Request for permission to do data collection at your school

1. With reference to the above matter kindly consider my request to collect data at your school.
2. The data is for my study in Masters of Science in Mathematics, Science and technology degree that I’m presently doing with the University of South Africa.
3. In this study the educators and learners in grade 10-12 will be sampled to participate.
4. Classroom observation will also be done when the computers will be used in teaching and learning Mathematics.
5. Your cooperation is always appreciated.

Yours Faithfully
Mavhungu LE

[Signature]
Request permission letter to the School

ENQUIRIES: MAVHUNGU LE
0726009029

58 Cronje Street
Makhado
0920

The Principal
Robert Mbulungeni Secondary School
01-08-2011

Sir

Request for permission to do data collection at your school

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2. The data is for my study in Masters of Science in Mathematics, Science and Technology degree that I’m presently doing with the University of South Africa.
3. In this study the educators and learners in grade 10-12 will be sampled to participate.
4. Classroom observation will also be done when the computers will be used in teaching and learning Mathematics.
5. Your cooperation is always appreciated.

Yours Faithfully
Mavhungu LE
The Principal
Ngnweni Sec. School
25-07-11

Sir

Request for permission to do data collection at your school

1. With reference to the above matter kindly consider my request to collect data at your school.
2. The data is for my study in Masters of Science in Mathematics, Science and technology degree that I'm presently doing with the University of South Africa.
3. In this study the educators and learners in grade 10-12 will be sampled to participate.
4. Classroom observation will also be done when the computers will be used in teaching and learning Mathematics.
5. Your cooperation is always appreciated.

Yours Faithfully
Mavhungu LE
Appendix K

CONSENT FORM

I am currently involved in a research project addressing the investigation into the use of computers in the teaching and learning of hyperbolic graphs in grades 10 to 12 Mathematics. The study is done in the fulfilment of a Master's degree in Mathematics Education at the University of South Africa.

Your participation in this project will provide useful information on this topic. You qualify to participate if you are between the ages of 15 and 65. You will be asked to complete a questionnaire and a scheduled interview will be conducted. Classroom observation will be done when the teacher uses computers to teach hyperbolic graphs.

Participation in this project is strictly voluntary. All the data of this project are confidential and will be used for research purposes only. Data from questionnaires and interviews are anonymous. Names of participants will not be connected to information and scores.

There are no foreseeable risks to the participants.

Thank you for your assistance.

Signature: ___________________________ Date: 18-04-2011

Name of researcher: Mavhungu Lavelani Emily

Telephone number: 0155166110
Appendix 1: Report on HeyMath Programme

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

Report on the HeyMath Programme

About HeyMath!

HeyMath is a world-class E-Learning program that supports the work of teachers and helps learners build a strong foundation in mathematics. HeyMath is used by learners in over 55 countries, has been a leading learning program in Singapore for the last 10 years and is also used by schools in India, US and South Africa.

HeyMath provides South African schools with technology-enabled teaching and assessment resources (formative and summative) aligned to the Grade 3–12 NCS Curriculum and backed by hands-on professional development support for educators. In order to roll out the programme in South Africa, HeyMath has partnered with a number of Provincial Departments of Education (KZN, NC and FS).

After visits by delegations to India and Singapore, the Limpopo Department of Education is introducing the programme in 300 institutions from 2011. The programme will be rolled out in these institutions for a period of three years. The programme will be evaluated at the end of the third year, and thereafter the department will decide whether to continue with it or not.

Identification of Institutions

300 institutions have been identified for the programme: 120 primary schools; 120 secondary schools; four (4) MASTEC centres; Glayan science centre and five (5) district offices. The list of schools includes Dinakini, Dinatsane, Dinakili Reserve schools and their feeder primary schools, state of the art schools and big enrolment schools.

Training of Subject advisors

The department planned to train 108 subject advisors (25 Foundation phase, 36 GRT, 53 FET and 14 Head office staff) who will be involved in ensuring the success of the programme.

Training of Subject advisors took place from 01 to 02 June 2011. 89 subject advisors were trained on how to use the programme and also on how to support teachers. All these subject advisors received a set of equipment (i.e. laptop, data projector and screen) and committed themselves to ensure the programme’s success in the province. In addition, five (5) CAT and IT subject advisors were trained on how to give technical support to schools.

Training teachers

The total number of teachers who are being trained on the programme is 580. Training started on 03 June and will end on the 14th June 2011. Schools are expected to send two Maths teachers each. They are attending in groups of about 120 each and training is done over two days. Training is done at Thumbeini EMPC. Teachers who are attending the training, each gets a set of equipment for the school.