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The Use of Educational Technology in Mathematics Teaching and Learning: An Investigation of a South African Rural Secondary School.

Mini-dissertation submitted by Mathomo M. Moila in partial fulfillment of the requirements for M.Ed. (CIE), University of Pretoria, 2006.

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Acknowledgements

Professor Johannes Cronje for helping, guiding and supporting me in this course from the beginning to the end;

Africa-America Institute in South Africa for providing me the opportunity of studying towards this degree;

Mr T. Mbhalati, circuit manager Shiluvane circuit in Limpopo for granting permission to do my study in Phusela secondary school;

Mr. J. Ramathoka, principal of Phusela Secondary School for allowing me to do the case study at the school and his help and cooperation given;

The educators and learners of Phusela Secondary School who were involved in the study;

Dad, Mom, Larry, Shoki, Mampuni and Jerry for your support, help and understanding during this journey I undertook. Thank you all.

Summary

The purpose of the study was to investigate the use of educational technology in Mathematics teaching and learning. In order to achieve this goal, a school by the name of Phusela Secondary was visited for the whole week to conduct the study.

A lot of the literature reviewed was on developed countries as there is limited literature on developing countries concerning the use of educational technology in Mathematics teaching and learning and rural schools. Learners achievements compared to the Solo taxonomy measured effective usage of educational technology.

The investigation followed a mixed method approach that was more evaluative and as one case was investigated it was a case study. Participants were sampled Mathematics learners who were willing to participate in the study and willing Mathematics educators of Phusela Secondary School.

It was found from the study that there are no plans on the use of educational technology tools in Mathematics teaching and learning, inadequate educators' training on the use of educational technologies in teaching and learning and lack of relevant educational technology tools for rural schools. These were the major reasons for the school not to use the educational technology tools in Mathematics teaching and learning. However these tools were sometimes used for other purposes other than Mathematics teaching and learning.

Recommendations were made on how Phusela Secondary School can improve its usage of educational technology tools in Mathematics teaching and learning effectively for the development of higher order thinking skills. Recommendations for further study in as far this study was concerned were made

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Key Words

Educational technologies in schools

The Mathematics teaching and learning

Information and Communication technologies (ICTs)

Educators' and learners' perceptions

The Solo (Structure of observed learning outcomes) taxonomy

Learners' achievements

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CHAPTER 1 Introduction

1.1 Introduction

The South African government has made a commitment to improve the Information and Communication Technology (ICT) skills of its people, and to bridge the digital divide by targeting previously disadvantaged groups. The idea is in line with the New Partnership for Africa's Development (NEPAD) to achieve a sustainable development in the 21st century (Department of Education, 2003). The study focuses on the use of ICTs in Mathematics teaching and learning, and determines whether there exists any relationship between the use of ICT and the learners' achievements using the Solo taxonomy. To attain this, an ICT pilot project in Limpopo province was investigated. The project's name is Thintana, and the school where in the investigation is made is Phusela Secondary.

1.2 Background to the problem

Thintana project is the first and only existing project in Phusela Secondary School that is involved with the installation of ICT tools and training of educators on ICT usage in teaching and learning. The project is piloted in more or less fifty schools in Limpopo province. Phusela has never had any computers prior to Thintana project until they were installed in 2000 at the school. Phusela is situated approximately 25 km from Tzaneen, which is the nearest town in Mopani district. The school is found in a township community called Lenyenye, which was under the jurisdiction of the former Lebowa Bantustan, but now under Tzaneen municipality. Like most of the schools of its type, the learners come from poor families, where unemployment is rife. The school has always been having electricity, a telephone landline and a night watchman. Phusela had a population of approximately nine hundred (900) learners and twenty (20) staff members. Two South African telecommunication companies, Telkom and Thintana sponsor Thintana project. Thintana is aimed at promoting and uplifting the education of historically disadvantaged people of South Africa. In working towards attainment of this aim the two companies agreed on funding an ICT project in rural South African schools. Of cardinal importance is that the project is aimed at equipping educators with the required skills in the use of ICTs in the classroom for the enhancement of education in the classroom. Through the project the recipients will gain the ICTs skills that will allow participation in the global information and communication technology, which are very vital for communities to stay competitive in the global village. However for the communities to appreciate and master the ICT skills, they should make sure that the project is sustainable as Grewan (2002) sees the precondition for sustainability is successful usage of ICT tools into the curriculum. This is emphasized by Rejaratman (2002) cochairman of Thintana who indicates that as schools are receiving these equipments for the first time, they might be excited for a while, and be stranded thereafter. In order to address the problem ten educators per school/center were to be trained on the use of ICT tools in teaching and learning.

1.3 The role of School Net South Africa (SNSA) in Thintana Project

School Net SA (SNSA) has been charged with the responsibility of managing and executing the project within the schools in which the project is piloted. This means SNSA was responsible for overseeing all activities related to Thintana project including setting up of provincial committees, selection of schools, training of educators and co-ordination of the evaluation of the project. However, the process of selection was delegated to provincial departments by SNSA. The criteria for school selection were (SNSA, n.d):

- Schools selected should include rural schools and have access to electricity; and

- Emphasis to be on Mathematics Science and Technology project schools.

The provincial committees were not to deviate from the guidelines indicated in the project on criteria for selection. In addition to that, SNSA requested schools that were applying to come up with a business plan of how they were going to utilize and sustain the technological resources in their communities. Business plans should cover issues such as the relationship of the school and the community, the role of the school leadership in terms of planning, management of facilities and finance, the school approach to teaching and learning, the role of staff in decision making, attitude of educators towards ICT tools usage and a plan for staff development and how management is going to support staff development (SNSA, n.d). This is very important as parents in most former disadvantaged schools cannot afford to pay school fees, and money is a contributing factor towards sustainability of the project. The implication being that schools would have to increase their school fees enormously which will not make sense if most of the parents don't afford the minimal that is being paid.

SNSA is an organization formed to create Learning Communities of Educators and Learners that use ICTs to enhance education (SNSA, 1999), and it was established in 1997. Its focus is on the disadvantaged communities. The SNSA is a champion in Southern Africa on the promotion of the use of ICT in teaching and learning in schools. Through its knowledge and expertise in the area of ICT-enhanced learning, the SNSA assists learners, educators and decision-makers to achieve their potential in contributing towards a better education for all by making them realize the capabilities of ICT in enhancing the quality of learning experiences and adding value to the process of teaching and learning. The challenge lies in using ICTs capabilities to achieve these results. Thus as educational practitioners, we need to look into what we are doing in education, and then we can consider those capabilities that the computer can offer (Woodhouse & McDougall, 1986). The ICT tools should not be considered as replacements for educators, but as tools to be used by educational practitioners and help them to achieve educational goals. The SNSA overcome the geographical obstacles, by making use of technologies such as e-mail and Internet, to introduce teachers and learners to the power of collaboration and the learning experience that a community provides (Roos, 2002).

In order to maximize its effectiveness, the SNSA develops programmes in teacher development and capacity building, content management and development of the schools. This in turn provides collaborative opportunities for strengthening the communities to which schools are linked. The SNSA's broad experience arises from its implementation focus, and proven ability to plan, negotiate, roll out and evaluate demanding projects. It is strategically positioned to contribute to the realization of national priorities in the education and training system, working towards a knowledge-based society, developing universal access to telecommunications and information, and educating the youth to participate in South African and international programs and activities (Grewan, 2002).

1.3.1 What is a schoolnet?

A schoolnet can be understood in the context of its structure, services and sustainability (Butcher, Addo & Isaacs, 2003). It is understood to be a group of schools connected to each other through ICT resources and are using these resources for interacting. The ICT tools need to be used effectively and ultimately schools need to be in a position to sustain the resources financially without relying on external sources for funding (Butcher et al, 2003).

1.4 The SOLO taxonomy

Solo stands for Structure of the Observed Learning Outcomes, which is a framework developed by Biggs (Biggs & Collis, 1982). According to Biggs and Collis (1982), the Solo taxonomy provides a systematic way of describing how a learner’s performance grows in complexity when mastering many tasks. It is a way of categorizing levels of learning in terms of increased learners’ comprehension (Biggs & Collis, 1982). Biggs and

Collis further indicate that for reaching a higher level, other factors like motivation and prior knowledge of a particular task must be considered.

The Solo taxonomy provides a general framework for showing how learning outcomes grow progressively to more complex levels at all age levels as learning proceeds. Biggs and Collis (1982) identified the following levels as the SOLO taxonomy:

- Pre-structural – In this level the learner has not understood the point. There is no interrelation between cues and responses. They are all fused into one tangled unit.
- Uni-structural – In this level understanding is nominal. Response is ascribed to one relevant feature and the relevancy of other features cannot be identified.
- Multi-structural – In this level there is no link among learnt aspects, as they are treated separately. Response involves several relevant features that are not linked.
- Relational – The components are integrated into a coherent whole with each part contributing to the overall meaning.
- Extended abstract – The components are integrated and reconceptualised. True logical deductions are demonstrated. Responses demonstrate application of principles to situations that are not given. That is, transfer of knowledge to other aspects is demonstrated.

The use of the level descriptors, like the Solo taxonomy provides a powerful tool to asses the outcomes of learning, and by implication the effectiveness of the learning activities (Jackson, 1998). The SOLO taxonomy has been applied to a variety of areas in mathematics and ICT (Davey & Pegg 1989, Watson & Moritz 1998, and Chick 1998 in Alsaadi, 2001). However the taxonomy cannot be used only to evaluate and classify learners' performance in terms of their exhibited structure into a hierarchy of levels of abstraction. In his work, Biggs (1999) argued that the Solo taxonomy could also be used to define curriculum objectives, which contain criteria for levels of understanding applied to the content in question.

In this study evaluation of the learners' performance is done in terms of their exhibited structure into hierarchical Solo levels. The reason being that in the South African secondary schools, two different curricula are being implemented at the same time. One is being gradually phased in while the other is being gradually phased out. Grades 8-9 are implementing Curriculum 2005 while grades 10-12 are implementing the interim syllabus. Curriculum 2005 is now being replaced by the Revised National Curriculum Statement (RNCS) and its implementation plan for secondary schools is 2007 in grade 8 according to the National Department of Education plan. The interim syllabus is to be replaced by outcomes based curriculum in further education and training (FET) schools and colleges. However at the time of the investigation in 2004, it was not yet finalized as to when the curriculum is to be implemented as indicated in Chapter 3. Therefore, in evaluating learners' achievements, decisions can be made on the effective usage of ICT tools in Mathematics teaching and learning.

1.5 Purpose of the study

The purpose of this study is to investigate the use of ICT in Phusela secondary school in Mathematics teaching and learning and to develop some strategies on the use of ICT in Mathematics teaching and learning for similar rural schools like Phusela Secondary School.

1.6 Research questions

The main question to this study is to investigate whether or not Mathematics teachers in Phusela Secondary School are using the available ICT in their teaching, and if so, how their use of ICTs relate to learners' learning outcomes. Specific questions that need to be addressed are as follows:

- To what extent are ICT tools used in Mathematics teaching and learning at Phusela secondary school?
- What are teachers' and learners' perceptions on the use of ICT tools in mathematics teaching and learning?
- How do learners' achievements in Mathematics compare to ICT tools usage in terms of the SOLO taxonomy?

1.7 Rationale

In my teaching years and schooling years Mathematics has been perceived as a problematic subject. This is supported by the annual Matric statistics, showing that of all the learners sitting for the Matric exam less than forty percent are doing Mathematics as a subject, and yet Mathematics is regarded as one of the key subjects that develop learners to be problem solvers which is what is required to stay competitive in the globalize village. It was during my study for a diploma in datametrics that I came to realize how ICT tools usage has changed the whole complexion of business, and thus I felt if ICT tools could be incorporated into education and be used correctly in the teaching and learning of Mathematics, then we could have more problem solvers, contributing positively in improving the way things are done in schools.

The use of ICT tools in teaching and learning of Mathematics has long been studied. However most of the studies were confined to developed countries like the USA, Britain and Australia. It was found in both pre-school and primary schools of Australia that the use of drill and practice software have shown to increase learners' achievements (Yelland, 2001). In secondary schools it was found that the use of ICT tools that support higher order thinking skills contribute positively towards Mathematics achievements. However, very little studies are done in developing countries. Therefore the focus on the importance of ICT tools in rural schools should be on how the tools can best enhance Mathematics teaching and learning given the enormous challenges that rural schools are faced with. But for these tools to be effective, educators must accept that they need to change the way they have been teaching. However this changing does not come automatically. Of importance to the correct meaningful change is the availability of the ICT tools and the support that management will provide in the educators' endeavor to customize themselves to the tools (Yelland, 2001).

Companies like Telkom, Thintana and SNSA who are willing to fund, initiate, administer, and support ICT projects in rural South African schools reinforce this idea. The findings from this research will benefit:

- Mathematics educators struggling to admit retain and exit more learners of quality in their classroom;
- SNSA on effective implementation of their project in rural schools; and
- Instructional designers, who designs technology mediated tools.

1.8 Research Limitations

The following were identifiable research limitations within which the study was conducted.

- The fact that I am not directly involved in the project and the school is a limitation since it is sometimes difficult to get all the necessary documents of the project, because the school management might think that the results can be used for punitive purposes. However the management of the school was assured that documents requested were to be used for research purposes only.

- The fact that only one school was investigated is in itself a limitation as the findings cannot be generalized, but will give a deeper understanding of the concerned school and can only be relevant to other pilot schools.
- The fact that the data collection instruments were written in English, which is the participants' additional language, was a limitation especially for learners' participants. A translation of the questions into participants' home language was done and participants were encouraged to respond in their home language. A tape recorder was used to record interview responds. However when transcribing the interview responds English was used.
- The fact that no prior Mathematics achievements were collected is a limitation. However by using the SOLO taxonomy there is no need to compare their past and present achievements, as SOLO focuses on how learners are demonstrating their deep understanding in responding to questions.

1.9 Research methodology

The research is of mixed qualitative and quantitative nature that is predominantly qualitative. According to Strauss and Corbin (1990) qualitative research broadly means any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification. Thus in this instance no statistical procedures was used to quantify the results or findings. The observer paid attention to participants' social context and try to understand the participants' social context, where data were collected at the participants' natural setting (Lincoln & Guba, 1985). The collected data according to Lincoln and Guba is rich in description and is more concerned with the process than specifying outcomes. For a clear understanding of the situations and events, interpretation of data is eminent.

A case study was conducted on the evaluation of Thintana program on the use of ICT in Phusela Secondary School, in Limpopo, on the teaching and learning of Mathematics.

According to Cohen, Manion and Morrison (2000) a case study is a specific instance that is frequently designed to illustrate a more general principle. The study concentrated on a specific case, which is more likely to easily identify things that are sometime hidden in a large-scale survey (Cohen et al, 2000).

The study took the following course:
A school was visited where in the observer:

1. Observed the following:
    - Educators Lesson plans (Mathematics);
    - Learners' Portfolios; and
    - Learners and Educators while working in class.

2. Interviewed:
    - Educators; and
    - Learners.

    The interview focused on participants' usage of ICT tools and their perceptions about these tools in Mathematics teaching and learning. Chapter 3 contains more details of this aspect.

3. Drew up a questionnaire for:
    - Educators; and
    - Learners.

    The questionnaire focused on the purposes that ICT tools are used for. The educators' questionnaire also focused on the competency and frequency of ICT tools usage. Chapter 3 contains more details of this aspect.

1.10 Structure of the research report

The study consists of 5 chapters. The arrangements of the chapters take the following format:

- Chapter one provides a general overview of the study. It introduces the research problem and explains on how the research is to done.
- Chapter two is a review of literature of the research problems based on questions asked in chapter one, from which the conceptual framework is derived.
- Chapter three provides a description of the research methods that were employed during the study.
- Chapter four provides a detailed report of the results obtained during data collection.
- Chapter five gives a summary of the findings and analyses them in terms of the literature reviewed in chapter two. It gives conclusions and recommendations drawn from research and includes recommendations for further research.

Chapter 2 Literature review

2.1 Introduction

The integration of information and communication technologies (ICTs) in Mathematics teaching and learning in our South African rural schools is a challenge that can have far reaching consequences if not properly done. Educators are faced with the problems of having two parallel curricula in one school as the interim syllabus is being gradually phased out whilst outcomes based education (OBE) is being gradually phased in. Educators are still struggling to get grips of the new curriculum, which is a major challenge on its own. Thus there might be a lot of reluctance in as far as ICT integration is concerned, more so because most of our South African rural schools get their ICTs resources through donor collaborations. The literature review focuses on challenges that rural Mathematics educators and learners face in their endeavor, in using ICTs in teaching and learning. The following aspects are considered as being important in this review:

- What constitutes an effective ICT usage in a meaningful Mathematics teaching and learning situation?
- How do educators and learners perceive ICT usage in Mathematics teaching and learning?
- What is the status of Mathematics achievements terms of SOLO taxonomy?

Most of South African rural schools that have computer laboratories are pilot projects. Thus not much of ICT usage in Mathematics in rural South African schools has been researched. Due to this a lot of international literature was reviewed. Information acquired from the literature is divided into the following categories:

- The Mathematics teaching and learning situation;

- Use of ICTs in Mathematics teaching and learning;
- Educators' perceptions towards the use of ICTs;
- The use of ICT in Education;
- The use of ICTs in rural schools;
- ICTs usage and learners' achievements; and
- The Solo taxonomy.

2.2 The Mathematics teaching and learning situation

There is an alarming concern about success or lack of success of Mathematics teaching and learning in South African schools. This concern is supported by a study called "The Third International Mathematics and Science Study" (TIMMS) (Howie, 1999), as well as the South African government (Mangena, 2002). From the 1999 TIMMS repeat report, it is indicated that South African learners performed poorly compared to all other countries that participated in the study, even below the other African countries that took part (Howie, 1999). When the report focused on provincial achievements, it was found that Limpopo province performed below all the other provinces. This, according to Grayson (n.d) and Jarret (1998), is attributed to the fact that Mathematics teaching and learning in South African schools is often focused on memorization of facts and formulae. Learners also showed lack of Mathematics problem solving skills and higher order thinking skills, which cannot be easily developed in memorization of facts and formulae. From this result, it is evident that any form of intervention that will contribute to the enhancement of development of the mentioned mathematical skills would be strongly welcomed. In order to develop these skills, the use of ICTs resources in Mathematics teaching and learning becomes inevitable (Jarret, 1998).

Based on one of the principles of the outcomes based education (OBE), which is gradually being introduced in our education sector, there is provision for the development of high skills and knowledge. The implication of this for the teaching and learning of

Mathematics is that there should be a move from emphasizing memorization of facts by learners to a more learner-centered approach where learners enhance on their questioning, elaboration, explanation and other verbalization mechanism, which contribute to the development of problem solving and higher-order thinking skills in Mathematics. Hersh (1998) in Golafshani (2002) indicates that: “The issue is not, what is the best way to teach? But, What is Mathematics really about?”(Golafshani, 2002, p.1)

The reason for the concern about higher level of mathematical skills and knowledge is that Mathematics is the basis of many successful careers and lives (Golafshani, 2002). Therefore, there is a need to make our learners knowledgeable and skillful in mathematically inclined careers, especially for rural schools like Phusela because rural communities are the majority of underdeveloped areas of South Africa. Golafshani (2002) defines Mathematics as ideas that one possesses and it is out of these ideas that Mathematics can be developed. For effective development of these ideas, the Mathematics teaching and learning should be learner-centered and give learners opportunities to explore and investigate their ideas (Golafshani, 2002). Golafshani further indicated that in the process of exploring and investigating, emphasis should be on problem solving, cooperation among learners and showing how the Mathematics concepts relate to the learners’ everyday life. Adam and Hamm (1996) point out the importance of cooperation in Mathematics learning in demystifying the perceptions that many people have about Mathematics. They indicate that many people perceive the study of Mathematics as an isolated, individualistic and competitive matter that can only be mastered by a few talented individuals. Adam and Hamm (1996) see cooperation in Mathematics as:

- Providing a social support mechanism for Mathematics learning, which is attained when learners ask questions, discuss ideas, make mistakes, and learn to listen to others’ ideas, offer constructive criticism, and summarize their discoveries;

- Offering opportunities for the success of all learners in Mathematics because the group interaction is designed to help all members to learn effectively; and
- Making learners to benefit from the different approaches used in their discussion because of the objective nature of Mathematics solutions.

A deep understanding of the mathematical teaching and learning environment gives guidance on the approaches that educators can employ in teaching the subject. Also educators should be aware of the conditions under which learning could be effective. A deep understanding of the Mathematics teaching learning environment imply that educators will know when and how to use the ICT resources and for what purposes in Mathematics.

2.2.1 The Role of the Educator in Mathematics Teaching And Learning

Golafshani (2002) sees a great deal of educators' conceptions about the content influencing their instructional practice. Golafshani went on further to indicate that educators who perceive learning as accumulation of information are likely to view teaching as a transfer of information. Thus these kinds of educators will pump a great deal of information into learners' heads. Their approach to teaching tends to be more educator-centered, and rote learning is usually encouraged. On the contrary, Golafshani also identifies another type of educators who perceive learning of Mathematics as helping learners to construct Mathematics for themselves. Their approach is more learner-centered and through learners' discussions, debates and questioning amongst themselves independent learning is encouraged.

In order for the Mathematics teaching and learning situation to be more meaningful and authentic, there is a need to come up with the learning environments that support learner-centered approach and de-emphasize rote learning. Thus it is the responsibility of the educator to understand what learners need to know and should be able to do, have an immense mathematical knowledge and appropriate instructional strategies to meet the different learning styles of the learners. In de-emphasizing rote learning, emphasis will now be on development of high order thinking skills and problem solving in Mathematics.

The educators' belief systems on Mathematic play a very important role on how the educators are going to approach their teaching. Sugar, Crawley and Fine (2004) see these belief systems influencing the educators' teaching philosophy. A research carried out by Chen and Arvold (2002) in the USA; found that educators' belief systems influence the learners' image of Mathematics. They went on further to indicate that educators who are aware of their belief system might use this to expand or not expand learners' image about Mathematics.

The educator's understanding of Mathematics is of paramount importance, as it will influence the depth at which Mathematics is taught. The educator will always be confident in what is being done with the learners in class and is not threatened by the learners. Such kinds of educators are likely to motivate and encourage their learners to develop a positive attitude towards Mathematics, which will in turn improve development of a positive attitude and learners' performance in Mathematics (Higgins & Moseley, 2001).

2.3 The use of ICTs in Mathematics teaching and learning

There are high expectations for ICTs usage in improving the teaching and learning of school Mathematics internationally by educational researchers (Kaput & Roschelle, 1997). However it is only in England, USA, Singapore, Canada, Hong Kong and Korea that the study of computer usage has shown a noticeable increase (Ruthven & Hennessey, 2002). Ruthven and Hennessey went on further to indicate that for the majority of other countries usage remains low and growth is very slow. According to the Teacher Training

Agency (2002) the use of ICT in Mathematics should emphasise employing ICT to meet the needs of the learners in Mathematics and not teaching technology skills, as the technology is supposed to support Mathematics teaching. However the ICT skills are needed to be able to manipulate the ICT resources available. Thus a balance should be struck between ICT integration in teaching and learning and ICT literacy. According to Wilson (2000) appropriate uses of ICT tools can enhance Mathematics teaching and learning, support conceptual development of Mathematics, enables mathematical investigations by learners and educators and influence how Mathematics is taught and learnt. Kerrigan (2002) in Mistretta (2005) 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 – Calculators and graphic calculators accelerate the speed of learners when solving mathematical problems which results in more accurate results and improved learners confidence in Mathematics;
- Introducing learners to collection and analysis of data – Databases and spreadsheets give the learners the confidence of analysing large amount of data accurately;
- Facilitating learners algebraic and geometric thinking – Geometric software and algebraic systems offer learners a bridge from the abstract world of Mathematics to the concrete world wherein learners are able to create and observe numerical representations, Symbolic representation and geometric representation; and
- Showing the learners the role of Mathematics in an interdisciplinary setting – Integrated Mathematics packages allow learners the opportunities to explore problem-based learning.

Oldknow and Taylor (2002) indicate that ICTs offer young children the ability to explore and solve problems involving large numbers at an early age, investigate characteristics of shapes using dynamic geometry software and organize large sets of data. They further indicate that ICTs offer educators options for adapting instructions to special needs of learners that is unlikely in a traditional Mathematics class. The educator can always come with activities for different levels of learners that are in class, and learning occurs at the pace of the learners. Therefore the possibilities of engaging learners with special needs in Mathematics are increased and everybody can do Mathematics. Mathematics is not viewed in isolation but from multiple perspectives and thus the range and quality of investigations are enriched.

Even with the mentioned benefits of ICTs in Mathematics teaching and learning, there is very little provision to support the acquisition of appropriate curriculum software in Mathematics. Most of the software found in schools are generic or basic and usually come with the hardware when purchased as a package (Oldknow & Taylor, 2002). Therefore, when using ICTs in Mathematics teaching and learning environments, consideration should be on effective usage of ICTs (Bottino, 2004). This means looking at how educators and learners will be using the ICT resources, the effect the ICTs resources will have in the Mathematics teaching and learning environment, appropriate type of ICT resources that will support the teaching and learning environment and good pedagogical practice with the ICT resources.

2.4 The educators' and learners' perceptions towards the use of ICTs

Use of ICT into the classroom is being promoted worldwide. There are claims that successful usage of ICT into the classroom will lead to enhanced learning outcomes (Cope & Ward, 2002). According to Honey, Culp and Carris (2000) in Cope and Ward (2002) these claims are difficult to justify. According to Mumtaz (2000), the educators' perceptions on the role of ICT is very important as this will impact on how they are going to integrate ICT in Mathematics teaching and learning. A research conducted by Cope and Ward (2002), in Australian high schools, investigated educators' perceptions on what constitute ICT tools and how the tools impacted on learning. The result indicated that educators have varied perceptions of what ICT tools are. According to Cope and Ward (2002), the varied perceptions will have an impact on how educators are to use the ICT tools in Mathematics teaching and learning.

There are also varied perspectives on the educators' use of ICT in teaching and learning (Bebell, Russell & O'Dwyer, 2004). These varied perceptions on the educators' use of ICT and what constitute educational technology have an impact on the planning and implementation of educational technology. Also Beyerbach, Walsh and Vannata (2001) agree with Cope and Ward (2002). According to Beyerbach et al (2001) if one has narrow view of what educational technology is and how the technology might be used in the classroom, they will see the technology as a constraint in the teaching and learning situations, but if one has a wider view of what educational technology is and how it might be used in the classroom, they will see the technology as an empowerment. Thus it is important to move educators' perceptions from a narrow to a wider view so that educators should see the technology as an empowerment and not a constraint. A study done by Cox, Preston and Cox (1999) in Mumtaz (2000) has found that educators, who perceived the technology to be, useful for their personal and teaching work, were regular users of technology and has developed confidence in using the technology. Thus the educators' perceptions toward technology result in attitudes developed towards technology use.

Most of the studies done on learners' perceptions on ICT usage are on Internet enabled learning environments (Bennet & Lockyer, 1999). A study carried out by Tierney, Kieffer, Stowell, Desai, Whalin, and Moss (1992) on the Apple Classroom Of Tomorrow (ACOT) of six learners observed a shift in learners' view of computers. They view computers as tools that can help them to achieve their goals and develop and communicate their ideas (Tierney et al, 1992). Also a study conducted by Watson (1998), in Tennessee USA, in the Internet enabled environment, has found that learners think that use of ICT tools has made them to gain self-confidence and are in control of how to use the tools for their school work. When they are confident it shows that they see the value of ICT tools in their learning. Being in control on ICT tools usage imply that they are encouraged to use these tools more frequent.

Educators that are using ICT in teaching and learning are doing so because they see the use of ICT resources in teaching and learning helping them to be better educators, or the use of ICT tools will help them in improving their classroom practice (Higgins & Moseley, 2001).

2.5 The use of ICTs in education

The term ICT stands for information and communications technologies, which according to Whitten and Bentley (1998) describes the combination of computer technology (hardware and software) with telecommunications technology (data, image and voice networks) that enable processing, exchanging and management of data, information and knowledge. These equipments allow users to access, retrieve, store, organize, manipulate and present information by electronic means. Examples include:

- Scanners, computers, and projection equipment classified as hardware;
- Database, spreadsheet, and multimedia software programs classified as software; and
- Fax machines, teleconference phones, and modems classified as data image and voice networks.

The use of ICT in education has evolved with the development of computer technology. In the olden days the computers were big, slow and very expensive. With the development of technology they are small, cheap and fast. Together with other technological devices, they generate and process information quickly. Thus information becomes quickly and easily accessible. However, this remains true for developed countries. For developing countries, it is a challenge they have to face if they want to survive and stay competitive in the global village (Haddad & Draxler, 2002).

Minister Asmal (2003) in his foreword on Draft White paper on e-education states:

> Information and communication technologies (ICTs) are central to the changes taking place throughout the world. Digital media has revolutionized the information society and advances in ICTs have dramatically changed the learning and teaching process. This has opened up new learning opportunities and provided access to educational resources well beyond those traditionally available (Asmal, 2003 p.4).

With lots of changes going on worldwide, education is also not left behind. There is a need to meet these changes in education. Haddad and Draxler (2002), state that in order to meet these changes in education, there is a need for paradigm shifting as exemplified in table 2.1. It shows a move from an educational model in industrial age to a model in the information age (Haddad & Draxler, 2002). Because it is going to be difficult to use ICTs effectively using the industrial age model, it appears that evolution of the educational model of industrial age to an information age model is inevitable.

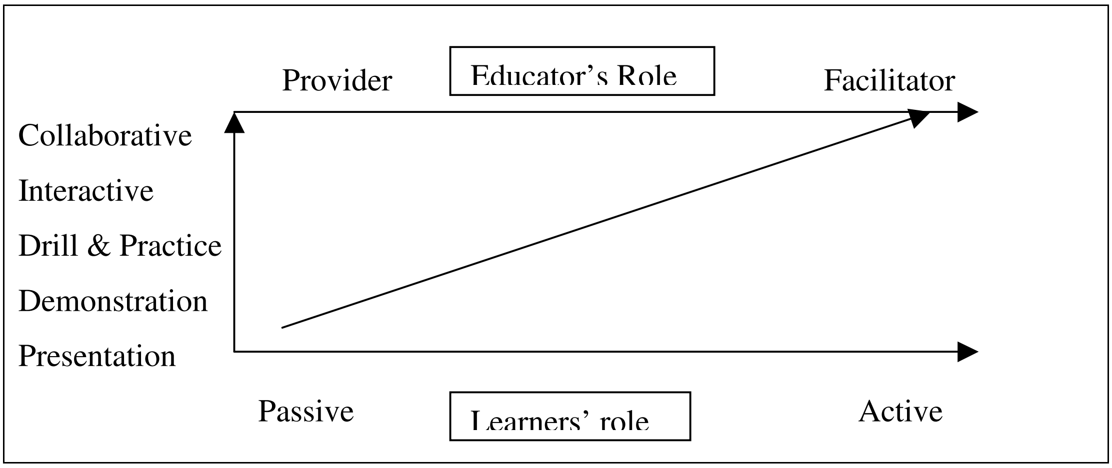
Table 2.1: The new schooling paradigm

From	To
A school building	A knowledge infrastructure (schools, labs, radio, television, Internet museums…)
Classrooms	Individual learners
A teacher (as provider of knowledge)	A teacher (as a tutor and facilitator)
A set of textbooks and some audiovisual aids	Multimedia materials (print, audio, video, digital …)

Source: Haddad & Draxler (2002, p. 8)

Due to this paradigm shift countries may realize the potentials of the different ICTs that suit their environmental condition. Haddad and Draxler (2002) add that teaching and learning practices need to be reviewed and realigned for accommodating meaningful use of ICTs in teaching and learning. Figure 2.1 is a diagram taken from Haddad and Draxler indicating how changed teaching and learning practices could be reviewed.

Figure 2.1: Use of ICTs for different roles of educators and learners



Source: Haddad & Draxler (2002, p.13)

The bottom x-intercept indicates the learners' roles as they change from the educator-centered approach, to the learner-centered approach. The top x-intercept indicates the educators' role as they change from the educator-centered approach to a learner-centered approach. The y-intercept indicates the different use of ICTs, which are more dependent on the teaching and learning practices starting from an educator centered role to a learner-centered role. It is evident that moving from a provider to a facilitator role does not come automatically because ICT resources are available in schools. It is also the responsibility of the educator to ensure that learners also move from a passive role to a more active role in the learning environment. Wheeler (2000) indicates the following as reasons for the new changed roles in the ICT learning environment:

- There will be management of distributed learning environments. From figure 2.1 the educator requires to engage learners in more collaborative activities, which are in essence learner – centered and do promote the learners' active participation in the learning environment.

- Learners need to be encouraged to develop their critical thinking skills, advance their information literacy and nurture their collaborative working practices so as to prepare them for the information which is more competitive than ever.
- ICT learning environments can be adapted to meet different learners' needs. The use of voice, visuals and simulations are suited for different learners' learning styles.

However for these changing roles to be realized there need to be investment in skill development for both educators and learners.

Striking a balance between training in ICT usage and the potential that the different ICT resources is offering is of important in showing the benefits of ICTs in education. Butcher, Addo and Isaacs (2003) identify the following as benefits of the use of ICT in education:

- Delivery of educational resources- ICT can provide immediate and updated resources. This implies that information can be always and easily be updated if done electronically, and it is easily accessible.
- Facilitating communication- ICT can support a variety of communications strategies amongst learners and between learners and educators. This can be done either individually or in groups.
- Facilitating interaction in resources- Learners at different levels are able to interact irrespective of geographical demographics with ICT resources.
- Building and exploiting information bases- Effective strategies are developed for storing information in ways that will allow it to be effectively and easily manipulated, stored and retrieved.

Jarret (1998) identifies the following as opportunities that ICT tools can offer today:

- ICT tools serve as a bridge from concrete to abstract thinking in adolescents, enabling them to create and observe multiple representations;
- Educators are able to create rich environments by responding to learners' diverse learning styles and the learning environment will include visual, auditory and a combination of visual and auditory senses, which result in long-term memory; and
- Higher order communication and problem solving skills are developed through tools like word processors, calculators, spreadsheets, Internet and etc.

With the benefits and opportunities that ICT tools are offering in the learning environment, it is important to focus on their meticulous use in order to realize these benefits and opportunities they offer. The path from the benefits and opportunities to their effectiveness is not implicit (Haddad & Jurich, 2002). Cuban, Kirkpatrick and Peck (2002) indicate that there is an assumption that putting ICTs tools in schools will lead to "abundant use" by both learners and educators, and the use of these tools will therefore result in improved teaching and learning. Their findings from the Silicon Valley research classified the majority of the community as composing of a range of seldom users, occasional and non-ICT tools users. An insignificant minority could be classified as widespread users. Cuban et al (2002) explanation for no use is as follows:

- Unchanging school structure even after the introduction of what Zhao and Frank (2003) called "new specie in the ecosystem"(p.810);
- Educators not having enough time to find and evaluate the software;
- ICT usage training seldom being offered at convenient times; and
- Training being irrelevant for specific educators' needs.

Zhao and Frank (2003) add on further to indicate that educators' attitudes and expertise towards ICT tools contribute to widespread usage. They identified compatibility to the teaching and learning environment and systematic and organized professional development as factors that contribute to widespread use.

While ICT tools can be used for different purposes in teaching and learning, their usage should be guided by the goals of the curriculum in order to bring in positive change.

2.5.1 Reasons for ICTs usage in Education

Clements (2000) indicates that computers in the classroom contribute to cognitive development. He further explains the different ways in which computers can be introduced in a classroom, which correspond with research conducted by Means (1994), Bruce and Levin (1997) in Taft (2000) on the application or uses of computers in the classroom. For them, the technology takes the following form:

- Training tool- Learners can use technology in online quizzes, drill 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 networks levels that are available.

These technological applications, which support learning in the mentioned ways, are often described as cognitive tools (Lajoie & Derry, 1993 in Oliver, 1999). Oliver (1999) sees the critical attribute of the cognitive tools to be the forms of learner activity and engagement that they support and encourage, not the information and knowledge that they carry. Bearing in mind the varying functions of the technology, it will be much easier for educators to start from the goals of their learning activities and then see which technology is relevant for them. This will help in eliminating the use of technology in a wrong or less than successful manner in the classroom.

According to the Department of Education (2003), it is indicated that effective usage of ICT resources enhance creativity, problem solving, high order thinking skills and reasoning. Capper (2003) adds that technology is seen to support the following educational goals:

- Improve teaching and learning in content areas;
- Develop learners skills considered to be essential in the modern world;
- Increase motivation for teaching and learning;
- Change the social organization of the classroom to be more learner centered;
- Enrich interaction among learners, teachers and other schools; and
- Creativity and collaboration.

Geisert & Futrel (2000) observe that the use of ICT for assessment facilitate teaching. According to Geisert & Futrel (2000), data analysis techniques have potential of tracking learners' achievements and review teaching strategies according to insight gained. Also ICT has the potential of increasing the efficiency and effectiveness of management and administration. The databases applications, spreadsheets, statistical analysis, etc make the work of the managers a lot easier and more manageable.

Dellit (2002) does not however see ICT automatically enhancing teaching and learning. According to her, ICT can be used for destructive purposes and further entrench inequalities and favors particular groups. She gives an example of evidence of a research carried out in the USA by Wenglinsky (1998) and Kreuger (2000), which found that African and Hispanic students are given more repetitive drill and practice tasks on computers and fewer sophisticated simulation applications than their white peers. Capper (2003) indicates that research in a number of countries has found that technology in education has really supported the mentioned educational goals. However, this depended on a number of aspects such as educators' readiness, willingness, motivation, and enthusiasms, and the structure of the curriculum (Capper, 2003). For a curriculum that is syllabus-oriented, educators are rushing through to finish the syllabus as expected by the government and not much time is given for lessons supported by the technology, which is the case in South Africa in further education and training band in South Africa. Cuban (2001) also identified the following as limitations on the use of technology in schools:

- Hard to control working conditions which schools find themselves;
- Pressure from outside on educators; and
- The inherently fast life span of the technology and its unreliability.

But according to Steketee, Herrington and Oliver (n.d) there is an agreement that ICT has an impact on teaching and learning. But its impact is not dependent on the extent, to which the technology is used in teaching and learning, but how it is used and for what purpose it is used in teaching and learning.

2.6 The use of ICTS in rural schools

There is a strong assertion on the benefits of ICT in our schools, especially for developing countries, as ICT is seen as a tool that will prepare learners for the information society they will inherit (Mfum-Mensah, 2003). The Department of Education (2004), indicates that ICTs are seen as resources that can reduce poverty in developing countries by overcoming obstacles of social and geographical isolation and increase access to education. The ICT in rural schools is seen more as a political issue, as in most instances the aim is to address equity with regard to access to opportunities for improving people quality of life (SNSA, n.d; Pedro et al, 2004). Despite the good promises that ICT resources are making, rural schools have enormous challenges in integration of ICTs into their teaching and learning. In the South African context they are seen to be addressing access, equity and imbalances of the past system, which was characterized by overcrowded classrooms in majority of learners, incompetent educators, and unfair distribution of resources across the color line (Department of Education, 2004). In South Africa, rural schools are a larger proportion of the schools. Lack of resources and facilities are characteristics of rural schools than their urban counter parts (Herselman, 2003; Mfum-Mensah, 2003).

Even after almost five years of government, private sector, parastatals and non-governmental organization efforts of bridging the digital divide in South African schools, there are still some disparities in the ICT integration by provinces.

Table 2.2 is an indication of the disparities existing in terms of acquisition of ICT resources according to different provinces. From the table it can be deduced that Western Cape, Gauteng and Northern Cape have made significance progress on provision of ICT resources. Limpopo is the least ICT providing province. As the province is predominantly rural this poses an immense challenge for the province.

Table 2.2: Schools with computers according to provinces (2002)

Provinces	Schools with computers	Schools with computers for teaching and learning
Eastern Cape	8.8%	4.5%
Free State	25.6%	12.6%
Gauteng	88.5%	45.4%
Kwazulu-Natal	16.6%	10.4%
Mpumalanga	22.9%	12.4%
Northern Cape	76.3%	43.3%
Limpopo	13.3%	4.9%
North West	30.5%	22.9%
Western Cape	82.4%	56.8%
National	39.2%	26.5%

Source: Department Of Education (2004, p.5)

Geographical location is also a limitation on access to information and the use of Internet in the majority of the rural schools. Castello (2002) in Herselman (2003) indicates that the geographical location should not be a limitation to access to information and Internet because they are important aspects for the promotion of learning.

According to Pedro et al (2004), the following were found to be ICT implementation constraints in Chile:

- Geographical isolation and inadequate infrastructure, which had a negative impact on the educators training program;
- Multi-grading problems due to low population density;
- The social and professional isolation that rural schools suffer due to the cultural relationship that exist between the school and the local community which normally lack technological resources.

They also indicated how the Chilean rural schools tried to overcome the mentioned constraints. For example, involving rural development initiatives from private sector and public sector working cooperatively with schools, helped to solve issues of geographical isolation and infrastructure.

Similarly Herselman (2003) identifies three challenges that rural schools encounter in their usage of ICT in South Africa, but labels them drawbacks as follows:

- Basic drawbacks- issues that rural schools need to conquer before any ICT connection can be done for improving access to quality education. They include lack of buildings and stationary, remotely situated rural schools and lack of experienced and skilled educators.
- Communications drawbacks- issues that limit rural school access to local and global networking systems. They include lack of telephone facilities, lack of

computers hardware and software and lack of technical training on the part of educators. On the contrary in this project Telkom provided free Internet access to schools that were involved in piloting the project (SNSA, 1999). However the exemption was not life-long but for a particular period. Also the phone lines systems that most rural schools have. Most have the trunk call system, which is an inhibiting factor in terms of reliable Internet connection.

- Other Drawbacks- issues that do not directly relate to technology but have an impact on the education of rural learners. They include lack of library facilities, lack of transport facilities, large number of educator- learner ratio, and lack of electricity connections.

Herselman, like Pedro et al, came with what can be considered to be solutions to rural schools drawbacks. Private and public partnership should collaborate with the aim of providing the ICT resources that are suitable to rural environments. Learn O-vision units, Thintana project, Telkom super centers are all examples of private and public collaborations focusing on rural schools in South Africa (Callaghan, 1999 in Herselman 2003). Herselman also emphasizes the role SNSA is playing in using ICT to support education and training in rural schools despite the enormous challenges at its disposal.

The constraints under which ICT usage in rural school is implemented are very important in helping to determine the ICT tools that are relevant for rural schools. However the constraints are likely to foster an information age gap between urban or suburban schools and rural schools and also hamper on the use of the ICT tools in teaching and learning.

2.7 ICT usage and learners achievements

The relationship of ICTs tools usage with learners' achievements is complex as there is no general agreement as to what constitutes learners' achievements. In most studies, learners' achievements refer to learners' scores in their standardized tests (Wenglinsky, 1998). Kmitta and Davis (2004) define learners' achievements as their performance measured against standardized tests. The standardized tests are more on basic Mathematics skills and mere application of Mathematical rules (Cassady, 2002). Cassady indicated that standardized tests are mainly used to show proficiency at a particular grade or skill level, and they have very little provision of demonstration of high order thinking skills. However in this study learners' achievements is not measured against their performance on the standardized tests, but on how they respond to different Mathematics problems demonstrating their deep understanding and high order thinking skills in Mathematics.

Most of the studies conducted on the relationship of the ICT tools and the learners' achievements are meta-analysis and quantitative studies and thus their results could be generalized for most instances. Most of the studies are also of empirical nature. The studies were carried out mostly in the USA and Britain and have indicated that the ICTs tools have an influence on learners' achievements (Wenglinsky, 1998; Ringstaff & Kelly, 2002; Bryraktar, 2002 in Eng, 2005; Chrisman, 2003 in Eng, 2005). The USA studies have shown little significance positive effect as compared to British studies. This little significance positive impact was attributed to educators' views of teaching, as the orientation was more on transmission than on constructivism (Cox, Webb, Abbot, Blakely, Beauchamp & Rhode, 2003). Wenglinsky (1998) also found that the use of drill and practice has negative impact on learners' achievements in Mathematics.

The study conducted by the British Educational Communications and Technology Agency (Becta) (2002) reported that schools that had very good ICT resources and were making good use of those resources achieved better results than schools with poor ICT tools. Becta further indicated that good ICT learning is dependent on the following:

- Availability of appropriate ICT resources;
- Supporting school leadership;
- Appropriate teaching approaches;

- Management of ICT resources; and
- Effective usage of ICT tools to compliment existing educators' pedagogical practices.

However Clark (1999) came up with an argument that media will never influence learning. He believes that the use of adequate instructional learning will influence learning. That is, if there are more than one media or media attributes that give the expected goals, they do not influence the learning. The instructional methods are the ones that have an influence on learning. Therefore the ICT tools alone will never influence learning.

2.8 The SOLO Taxonomy and learners' achievements

The SOLO taxonomy has implications on the teaching and learning of Mathematics. In order to get a clear understanding of the implications of SOLO to Mathematics, first an understanding should be made on why should Mathematics be done in schools (Biggs & Collis, 1982)? According to Biggs & Collis Mathematics is done in schools for the following reasons:

- To socialize learners: This reason has two levels. The first level is the lower level that prepares learners to operate effectively in the society that rest so much of its decisions making on mathematical models and calculations. An example that can be cited is budgeting for ones family. The second level is the higher level, which requires an understanding of the kind of mathematical modeling and calculating that lie behind government, business, and trade decisions. In this level, learners are able to interpret and articulate implications of inflation rates, subsidies, currency exchange rates, etc on them as a community. Therefore informed decisions will be taken.

- To develop logical functioning: Biggs & Collis see the Mathematics school curriculum fostering the development of learners' power of logical functioning. Also, the nature of Mathematics enhances the development of logical functioning, encourages and practices logical functioning and reasoning. This can be seen in the way the Mathematics content is arranged, moving from the concrete to the abstract.
- To prepare Mathematics specialists: Biggs & Collis see the intention being the preparation of the few that have the ability and interest to become professional mathematicians and also others whose careers depend on mathematical –statistical type of reasoning for decision making.

Based on the above mentioned reasons simplistically, learners in the early years of elementary school would demonstrate a lot of uni-structural responses, multi-structural in the late years of elementary school, relational in junior secondary school and extended abstract from the senior secondary school. Thus a true understanding of the subject would imply that the learner is operating at the extended abstract level of the SOLO taxonomy.

The strength of the SOLO taxonomy lies in its ability to be used effectively across a number of subject areas, as it is not content dependent (Jackson, 1998). Jackson further indicates that test results cannot be used as a measure of learners understanding, as some tests do not really measure levels of understanding. However he went on further to indicate that analyzing learners' written responses provide a reliable measure of the learners' understanding. The fact that the taxonomy gives a description of learners' achievements in terms of deep understanding evaluation of learners' achievements becomes more authentic.

7.9 Conclusion

ICT usage in Mathematics teaching and learning is not consistent in different countries even though there are high expectations. Usage in Mathematics teaching and learning can benefit both the educators and learners provided tools are used appropriately irrespective of the frequency of their usage. Appropriate use of ICT tools implies that different tools foster different mathematical skills.

The belief system that educators have will influence their approach to teaching and learning. Good or bad perceptions about ICT usage in teaching and learning result due to educators' belief systems. A good perception about the ICT tools usage will influence what tools are used for, how they are used in teaching and learning and how often they are used.

There is no general agreement on the relationship between ICT usage and Mathematics achievements. Some of the studies conducted used the standardized tests, which have some methodological problems. American studies as compared to British studies have shown very insignificant differences. The SOLO taxonomy will indicate the learners' deeper understanding in Mathematics.

An attempt in this study is done to answer the following questions.

- To what extent are the ICT tools used in Mathematics teaching and learning at Phusela secondary school?
- What are teachers and learners perceptions on the use of ICT in Mathematics teaching and learning?
- How do learners' achievements in Mathematics compare to ICT usage in relation to SOLO taxonomy?

The next Chapter 3 describes the research methodology that will be employed in exploring the above-mentioned questions.

Chapter 3 Research Methodology

3.1 Introduction

This chapter describes the research methodology applied in the study, including the data collection method, the data collection instruments, the research population and the method of sampling used. The research methodology outlines and explains the relationship between the research problem, the data collecting instruments and the analysis of the research. According to Cohen, Manion and Morrison (2000), the aim of methodology is to help the researchers to understand the processes and products of scientific inquiry. This can be done through different data collecting techniques or strategies that are available and making meaning out of the collected data.

3.2 The research method

According to Tashakkori and Teddlie (2003) research methods refers to ways, techniques, or tools for generating thoughtful, accurate, and ethical data about a program and also ways, techniques, or strategies for manipulating the collected data. Cohen et al (2000) also agree with Tashakkori and Teddlie but they further indicate that methods are to be used as a basis for inference and interpretation, explanation and prediction. The study follows a mixed method approach that is evaluative, and it is a case study. It is a case study because the focus is on an instance in action (Adelman, Kemmis and Jenkins, 1980 in Cohen et al, 2000). The study is evaluative as it is investigating the usage of a particular mode of instruction and out of that investigation decisions will be taken based on the findings (Patton, 2002). As the study is assessing the current situation at Phusela Secondary School on the use of ICT in Mathematics teaching and learning in relation to the Solo level of Mathematics achievement, with this kind of evaluation, more informed decisions can be taken that will contribute to the improvement of the Thintana program at Phusela Secondary School and do not necessarily mean that they ought to be judgmental.

Similarly Airisian and Gay (2003) see the main focus of evaluation being decision making. Decision making process is concerned with the quality, effectiveness or value of the practices being investigated. However Pattori (1986) in Mertens (1998) does not see evaluation resulting in major decision making. Mertens (1998) notes that evaluation can be used to reduce uncertainties about decisions, which have to be taken but have an influence on program decisions.

A mixed method approach is used because the study is focusing on the relationship between use of ICT tools and learners' achievements in Mathematics which involves generating a theory and confirming it. Creswell (2003) identifies six approaches of mixed methods of research. The approaches are:

- Sequential explanatory strategy
- Sequential exploratory strategy
- Sequential transformation strategy
- Concurrent triangulation strategy
- Concurrent nested strategy
- Concurrent transformative strategy

The mixed method approach strategy that is used in the study is concurrent nested strategy, which is one of the classifications of mixed methods strategies identified by Creswell. According to Creswell, this strategy employs both qualitative and quantitative approaches concurrently, but there is a predominant approach that guides the research project. The other approach that is given less priority is embedded within the predominant approach. The main benefit of the concurrent nested approach is to give the researcher a broader perspective as a result of using two different approaches, as opposed to using only the dominating approach (Creswell, 2003). In the study, the predominant method is the qualitative approach while the nested one is the quantitative approach. There are also drawbacks of this approach and the main ones are lack of literature on guiding researchers through this process and advice on how to resolve discrepancies that occur between the two data types (Creswell, 2003). In the study both the qualitative and quantitative literature were previewed, for guidance through the research process.

3.3 Data collection methods and techniques

The primary data collection procedures were the interviews, observation and documentation. The secondary data collection procedure was a self-administered questionnaire. Data was collected in April 2004. One week was spent in Phusela Secondary School during data collection. Two application letters were written requesting permission to collect data at Phusela Secondary School at the beginning of February 2004.One letter was addressed to the circuit manager of Thabina circuit, Mbhalati T (see Appendix G) and the other was addressed to the principal of the school, Ramathoka J (see Appendices G and H).

3.3.1 Observation

Observations were done during the educators' normal working hours, from 7h30 to 14h30. The school's daily timetable was followed for conducting the observations and thus there were no class disruptions. The main focus of the observation was on the learners, educators, and technology interaction in the teaching-learning situation (see appendix I). The researcher was observing the educators, learners in their natural teaching and learning environment. An observation schedule was used to collect data. Patton (1990) in Cohen et al (2000) sees observation data enabling the researcher to enter and understand the situation that is being described. Similarly Mertens (1998) sees the interest of the researcher in an observation, as the observation of people's behavior as they naturally occur in terms that appear to be meaningful to those involved. Two types of observations are identified, namely observation and participant observation (Cohen et al, 2000). Spradley (1980) extends these by identifying different types of participation that are found in observation. In the study, the observer was not part of the participants, non-participant observation. The observer was also not actively involved in the observation process. Therefore a passive participation was done. In this type of participation the observer does not interact with the participants during the observation process (Spradley, 1980).

3.3.2 Interviews

Interviews were conducted after the observation and were conducted to individual participants. The interview consisted of two schedules of structured questions. The one schedule was for the Mathematics educators and the other schedule was for the Mathematics learners. The questions were written in English. As most of the learners are English second language speakers the observer had to translate the learners' schedule to the learners' mother tongue which is Sepedi especially for grades 8 to 10 learners. A tape recorder was used to record the responses. In this instance the interview was used in conjunction with other techniques so as to validate the other techniques used (Cohen et al, 2000).

Interviews were conducted during long breaks and after the official contact time of teaching and learning. This was done to observe the culture of teaching and learning as most of the data were collected during the official contact time in the form of observation. The educator schedule was administered to each educator who was involved in the study. Appendix C has questions that constitute the interview schedule for educators. The learners schedule was conducted on a sample of learners from grade 8 to grade 12 who are doing Mathematics as one of their subject/learning area. For each grade five learners were conveniently sampled for participation in the study. The formula used to get the five learners was,

Number of learners/n = 5, and

every n-th learner was sampled to take part in the study. Appendix D has the questions that constitute the interview schedule for the learners.

3.3.3 Questionnaire

Two forms of questionnaires were developed. One was given to learners and the other one was given to educators. They were self-administered questionnaires. They were structured questionnaires that both composed of close format, open –ended format and rating scale type of questions. The questionnaires were based on Christensen & Knezek (2001) instruments for assessing the impact of technology in education, but were contextualized for Phusela Secondary School.

3.3.3.1 The educators' questionnaire

The educators' questionnaire was arranged in the following format:

A- School resources.

The questions focused at the educational technology resources that Phusela had before and after the Thintana. Availability of resources as indicated in Chapter 2 does not imply abundance usage, however lack of resources is sure a contributing factor towards effective usage of ICT tools.

B- Training of educators.

The questions focused on the duration of onside training and distance training and continued support from the educators' tutors. Also the continuing usage of computers after training was looked into. As indicated in Chapter 2 professional development plays a major role for continued usage of ICT resources.

C- Use of educational technology in the classroom

The questions focused on the extent to which educators are using the educational technology in their classes and for what purposes. It is through how ICT tools are used that their benefits and opportunities can be realized.

D- Educators' perceptions about educational technology.

The questions focused on the educators understanding and preconceived ideas about the educational technology. Educators' perceptions have an influence on attitudes developed towards technology use.

E- Educational competence.

The questions focused on technological competency as indicated by Zhao and Frank (2003) of the educators in using the resources and also in their content subject in this instance Mathematics.

Appendix E constitutes educators questionnaire.

3.3.3.2 The learners' questionnaire

Generally the questionnaire focused on how often learners get access to the educational technology resources, learners' skills in manipulation of educational technology resources based on Taft (2000) classroom use of computers and their view on the importance of educational technology. Appendix F constitutes the learner questionnaire.

3.3.4 Documents and Records Analysis

The following documents were used for data collection:

3.3.4.1 Educators' workbooks

The main focus was on how educators were planning for technology integration in their respective classes.

3.3.4.2 Learners Portfolios

The main focus was on how learners present their answers in Mathematics, when asked to do different tasks. All the Mathematics sections that were treated were investigated. However, it was found during record analysis that only one Mathematics section, Algebra, was tackled in all the classes. The other sections, Trigonometry and Geometry, had not yet been treated.

3.3.4.3 Educators Network Module Compact Disc

Educators Network Module Compact disc is provided by SNSA, and it entails modules offered to all the educators of the schools that are piloting Thintana project. All modules are distance education modules, and when an educator completes all the activities in a particular module, he/she would have satisfied the requirements for that module. The main focus for the analysis of this document was to investigate the type of training and support SNSA was offering to involved educators.

3.4 Research population

The subjects of the study were supposed to be all the Mathematics educators of Phusela secondary school. However when data was collected, one of the educators did not want to participate and was excused. There was also a temporary educator who had just been appointed two weeks before the data collection process. The educator was also excused from participating. Ultimately, there were three educators who participated in the study instead of five as initially envisaged.

3.4.1 Sampling

Sampling was done on the learners, as they could not all be involved in the study. Each grade was represented by at least five (5) learners chosen in a convenient way and totaled to twenty-five (25). As the study was more of qualitative nature a small number of a sample size would suffice (Cohen et al, 2000). The sampling strategy used is non-probability because the study does not desire generalization of data, and the type of non-probability is convenience sampling. Convenience sampling involves selecting immediate and available research participants (Cohen et al, 2000). In Phusela respective class lists were used to select subjects conveniently.

3.5 Data Analysis

Descriptive and interpretive analysis will be used to analyze the data. Basic features of the data will be described and interpreted.

3.6 Research limitations

This study does not claim to be a general overview of rural schools but my personal thorough investigation of Phusela secondary school. As I am also not directly involved with the school and the project, getting all the relevant documents is sometimes difficult given the time that was spent at the school. Even though the data from records and documents is readily available and easily accessible, it lack objectivity, is unreliable and sometimes deliberately deceptive (Cohen et al, 2000). In this study documents and records analysis was done for the purpose of triangulating other methods of data collection used. Furthermore, the study focuses on further education and training and senior phase and does not address issues in intermediate and foundation phases.

3.6 Conclusion

The methods described in this chapter were used for obtaining findings of this study, which constitute chapter 4 of this essay.

CHAPTER 4 Data Analysis

4.1 Introduction

The use of computers in Phusela Secondary School is not different from any other school in developing countries. The earlier studies of computer usage in developing countries, have shown that these countries have more challenges in their ICT integration than their developed counter-parts, which are sometimes taken for granted (Herselman, 2003; Cox, Webb, Abbot, Blakely, Beauchamp & Rhode, 2003). These challenges will ultimately impact on computer integration in the developing countries schools.

The analysis was carried out looking at the educators' perceptions towards ICT usage and educators' frequent use of ICT in Mathematics teaching and learning. Also, the analysis dwelt on the learners' frequent use of ICT, learners' perceptions of ICT benefits and the learners' achievements in Mathematics using the SOLO taxonomy to rank the learners' achievements. Tables, figures and description of data were used to present the findings. Occasionally inferential statistics was used in relation to the population studied.

4.2 Background information

This section presents information about the participants who were involved in the investigation and their environment.

4.2.1 Background information of educators

Three educators out of a total of five Mathematics educators of Phusela secondary school participated in the study. Thus a 60% participation of educators was obtained. All the educators were blacks, but not from the same ethnic group. Two of the educators were of

Sepedi home language speaker while one was a Xitsonga home language speaker. There were two females and one male. Those who did not participate are all males.

The male educator has a 30 years teaching experience of mathematics in grade 12. The two female educators have 18 years each of Mathematics teaching from grade 8 to grade 11. All educators who participated in the study did not have computers at home. Their only access to computers was the school's computers.

4.2.2 Background information of learners

Twenty-five learners of a total of 645 Mathematics learners participated in the study. Thus a 4% participation of learners was obtained. All the learners were blacks and taking Sepedi as their home language. Six of the learners were males and 19 females with an average age group of 17. The high numbers of Mathematics learners was due to the fact that every learner in grades 8 and 9 was compelled to Mathematics as their Learning Area and the grades 8 and 9 combined enrollment was 449, which was a 70% of the total roll of Mathematics learners at Phusela Secondary School. For the five Mathematics educators this was an overwhelming number of learners. The worked out educator-learner ratio was 1:129, which is one of the characteristic of formerly disadvantaged rural schools.

All the learners are English second language speakers. Because their proficiency in English is low, the instruments had to be translated to their home language to facilitate the process of getting reliable information. All learners who participated in the study did not have computers at home and their only access to computers was the school's computer laboratory, which had a very limited number of computers.

Table 4.1 below indicates learner-computer ratio of Mathematics for different classes. It can be concluded from the table that most learners do not proceed with Mathematics in their grade 12. The grade 8 and 9 computer-learner ratio is a bit large which can be a barrier towards effective computer technology integration. The grade 10 to 12 computer ratio is an acceptable number and can be used effectively in cooperative learning (Pelgrum, 2001 in Ping, Teo, Wong, Khine, Sing, & Divaharan, 2003).

Table 4.1 Learner-computer ratio per grade

Grade	Total no of learners in class	Learner-Computer ratio
8	212	11:1
9	237	12:1
10	67	3:1
11	102	5:1
12	27	1:1

4.2.3 Background information of the environment

Phusela Secondary School started operating in 1987. It is a public secondary school catering for grades 8 to 12 learners. Learners of Phusela come mainly from Lenyenye Township where the school is situated. There are also a few that come from the nearby villages; namely, Marumofase, Mokomotsi and Ramokako. The data were collected on the last week before the school recess for the Easter in 2004 during April. Some of the educators of the other subjects were in the computer laboratory compiling mark sheets and schedules using the computers. One of the educators was typing a burial service program that was to be held on a Saturday of that weekend. Most of the educators were compiling the schedules and mark sheets manually.

4.2.4 Phusela Computer Laboratory

Phusela Secondary School has never had a computer laboratory before the introduction of the Thintana project. However the school had one TV set, a VCR and a number of scientific calculators before the Thintana project. For the school to build a computer laboratory from scratch it was going to be highly difficult. Therefore one of the classrooms was turned into a computer laboratory, which implied that learners' accommodation was sacrificed. The room is fitted with safety steel burglar proofs on the windows and the door for the computers safety and a security services has since been used. The room is ±25m² fitted with twenty computers. The computers were installed towards the end of 2001 and the beginning of 2002. The school does not have electricity problems. The laboratory was well ventilated with two oscillating fans and was always kept clean.

At the time of the investigation, the computers were placed in four rows of five computers each, where a pair row was facing opposite each other allowing learners to sit facing each other in a row, and not directly facing the instructor. Phusela Secondary School did not have a data projector or an overhead projector. The only resource that the educator can use for presentation was a chalkboard mounted to the wall in front in the laboratory. All computers in the laboratory were operational and connected to one operational printer, which was the only one available. The computers were connected through a server, and used Windows 2000 operating system. They had the following application systems: Internet Explorer, Acrobat Reader, Outlook Express, Norton Antivirus, Microsoft Encarta and Microsoft Office 2000 package, which included the following:

- Microsoft Word
- Microsoft Access
- Microsoft Excel
- Microsoft Publisher
- Microsoft PowerPoint
- Microsoft Outlook.

From the mentioned application systems, Microsoft Excel is the application software that is mathematically related. Otherwise there was no specific Mathematics software.

The computer laboratory was also provided with a free Internet access, which was part of the donation by Telkom. However Phusela's telephone bill was too high and thus there was a lot of restriction on the Internet access as one of the mechanism of saving on its telephone usage by the school management.

The Phusela computer laboratory did not have a timetable showing the times of usage of the laboratory by different educators and learners. The school did not have a policy on how the laboratory was going to be used, for what purposes and for further development of the laboratory. However, during the data collection period at the school, a few learners were once invited into the computer laboratory. They were invited by the laboratory manager who happened not be a Mathematics educator. The invitation was just impulsive as there was no plan on his daily activity that learners would be invited in the laboratory on that day at that time. The educator was showing the learners how to search information on Encarta and using of Microsoft word. All the learners that were invited were not doing Mathematics as one of their subject. Figure 4.1 is a picture of a view of the only computer laboratory that was established in 2001 by Thintana in a form of donation with a few educators in it. All educators who were working in this computer laboratory did not teach Mathematics.

Figure 4.1 A view of Phusela Secondary School computer laboratory.

The next three sections (4.3, 4.4 and 4.5) report on the responses based on the three main questions of the study, which are,

- To what extent are ICT tools used Mathematics teaching and learning at Phusela secondary school?
- What are teachers' and learners' perceptions on the use of ICT tools in Mathematics teaching and learning?
- How do learners' achievements in Mathematics compare to ICT tools usage in terms of the SOLO taxonomy?

4.3 The use of computer technology at Phusela Secondary School

The main question of the research was an investigation of computer technology usage in Mathematics teaching and learning at Phusela Secondary School. In order to get answers to this question the following sub-questions were asked:

- To what extent is the computer technology used in Mathematics teaching and learning at Phusela secondary school?

This question was further subdivided into the following sub-questions:

- What are computers used for in Mathematics teaching and learning at Phusela Secondary School?
- What is the level of computer technology usage at Phusela Secondary School?
- What mechanisms are put in to enable educators to use computers in Mathematics teaching and learning?

4.3.1 Educators training needs towards the use of computers at Phusela Secondary School

Section B of the educators' questionnaire focused on the educators training needs. The training needs focused on educators' computer skills before the training, the different computer systems and application systems educators were trained in and the support that was given to educators after training.

From the educators' responses, it was indicated that they all have never had any computer skills before the training provided for by the Thintana project. Training was done for three months for 1½ hour in the afternoons and it was only face-to-face due to Internet problems even though the training resource was meant for distance education. The venue for the training was at the school and participation in the training was open to all educators. Of the three educators that participated in the study only one attended the training of educators and was trained on the following modules:

- Word processing
- Spreadsheet
- Using web resources
- Using Internet to find information.

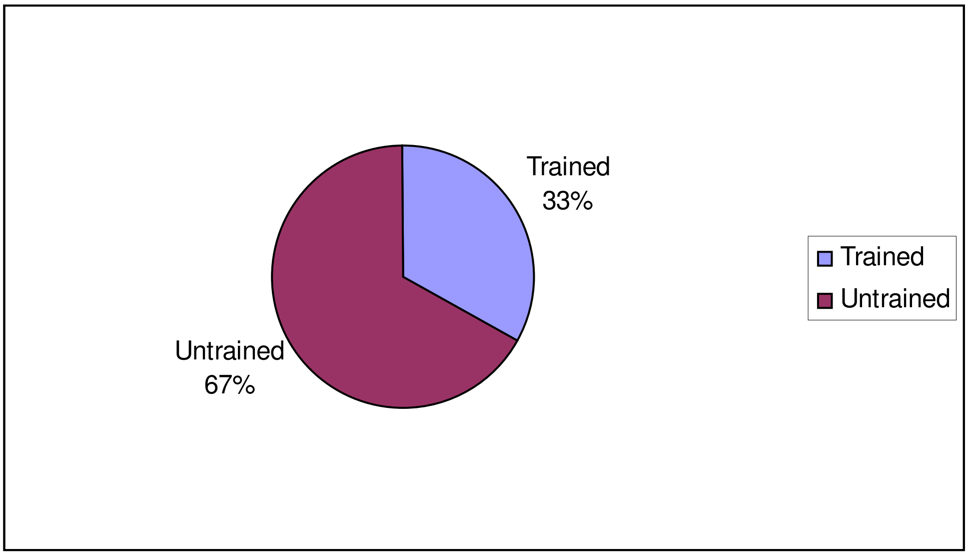
It implies that training focused on the mentioned four modules out of the seven modules developed by Schoolnet South Africa (SNSA). The seven modules developed for training of educators included the following:

- Word processing
- Spread Sheet for educators
- Using web resources
- Designing web page
- Finding information
- Questioning and thinking skills
- Assessing information

During training time of educators, there were no subject specific modules focusing at the different subject that are available. However later there were two other modules developed which are specifically for Mathematics and Physical Science.

Not all educators at Phusela secondary school were trained on Computer usage in teaching and learning. Below is figure 4.2, which gives a glimpse of educators who were involved in the training. One third of the educators were trained. This can negatively impact on the integration of educational technology in the teaching and learning.

Figure 4.2 Educators training composition.



4.3.2 Educators usage of computer technology in Mathematics class

Section C of the educators' questionnaire focused on computer technology usage in Mathematics teaching and learning. The first part of the section requested educators to indicate the frequency of usage of different technological tools. All educators indicated in their responses that they have never used those tools except for a calculator. It was evident from the responses that the Phusela Mathematics educators' most frequent usage of the technology tools was restricted to calculators. They were sometimes used in the classroom while teaching and also for many other purposes outside the classroom situation. All Mathematics educators do not make provision for computer integration in the classroom situation. The observation checklist for classroom interaction and review of educators' portfolios were used to triangulate data of section C in the educators' questionnaire. The portfolios did not show any evidence of computer technology usage in the educators teaching and learning. Everything that the educators kept as their records in the portfolios was hand written and there was no indication in their planning for any activity in the computer laboratory.

However the computer laboratory was used for other purposes outside the teaching and learning. During the data collection process a handful of educators will come, type and compile class lists and mark sheets. One educator came to type a burial programme for a burial of a relative that was to take place that Saturday which had nothing to with teaching and learning or the school administration.

4.3.3 Learners usage of computer technology in Mathematics class

In an interview one of the questions requested learners to explain clearly on what they were actually doing with technological resources in a Mathematics class. Twenty learners indicated that their usage of technological tools was confined to calculators for calculating, two indicated that they have never used any technological tool in a Mathematics class and three indicated that they were drawing and designing structures which were irrelevant concepts in Mathematics. The last two questions of the learners' questionnaire requested learners to indicate their frequency on ICT tools usage for different purposes at school and home. Almost all learner respondents indicated that they had never used computers at school or home. Even though the school had a computer laboratory learners were never invited into the laboratory for a Mathematics lesson. The laboratory had been in existence for the past two years when data were collected. If no Mathematics learner was ever invited into the laboratory, there are serious problems in relation to technology usage at Phusela Secondary School. The other reason for them not using computers was that they all did not have computers in their homes. However there was one learner who had just been registered with Phusela coming from another school having experience from the former school in computer literacy.

4.4 Perceptions about the use of computers in Mathematics teaching and learning at Phusela Secondary School

Both the educators' and learners' perceptions were investigated. To get a more detailed picture about educators and learners perceptions, a questionnaire was used. There was an educator questionnaire and learner questionnaire in relation to computer usage perceptions.

4.4.1 Educators' perceptions on ICTs usage

Section D of the educator questionnaire attempted to elicit information about the educators' perceptions on computer usage in Mathematics teaching and learning. To get reliable information, educators were asked to respond on a four point scale, ranging from (1) Strongly Disagree (SD), (2) Disagree (D), (3) Undecided (U), (4) Agree (A) through to (5) Strongly Agree (SA). Educators' perceptions on the use of ICTs were arranged into the following categories:

- Improvement of the overall performance of the learners in the school, motivation and encouragement of learners to love and enjoy their work and catering for the different learning styles;
- Improvement and relief of educators' administrative responsibilities and reinforcement of the pedagogical approach by creating a collaborative environment among colleagues;
- Effectiveness as opposed to traditional approach; and
- Replacement of educators.

Of the mentioned categories all the respondents showed a strong positive perception about the first three categories. A strong positive perception about the technology will result in a positive attitude about educational technology usage. Even though they have a positive perception on the educational technology use, one respondent raised a concern of learners relying more on the technology and thus not acquiring the Mathematics skills, knowledge, values and attitude necessary in today's life, which is influenced so much by technological developments. However the respondent was not aware that it was her responsibility to avoid those kinds of the consequences as the educator. On the fourth category two of the responded indicated a positive perception but was not very strong whereas the other responded was undecided. Surprisingly the responded who was not sure about this category was the educator who had undergone Thintana training. It can be deduced that even after undergoing training on technology usage there is still lack of understanding of the role of technology in teaching and learning.

4.4.2 Learners' perceptions on ICTs usage

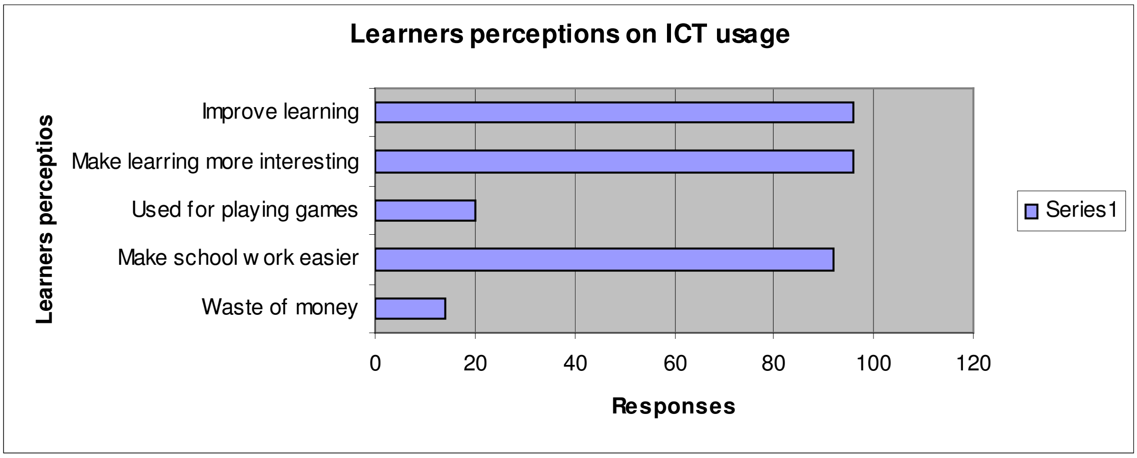
The learners' interview schedule focused much on their perceptions on computer usage. From the responses, it became evident that learners had a strong positive perception about computer usage in Mathematics teaching and learning even though almost all of them had very little access or no access to computers in their school. As the school does not have any plan or policy on how it is going to use ICT tools in teaching and learning, it shows that there is a lack dedication and commitment from management on ICT tools usage in the school.

Most of the learners indicated that computers make learning more interesting and easy, but were unable to explain how computers do that. A few that could explain about how computers affected their learning included aspects like independent learning and preparations for better job opportunities. An example mentioned on independent learning was the Television program "School TV" showing on SABC channels that could be watched during the school holidays. However what could be gathered from the responses was as if the technology could independently take over the teaching, and replaces educators, which is a misconception. There was no clear indication of how computers could prepare them for better job opportunities. Besides the overwhelming numbers of learners seeing the technology as contributing positively in teaching and learning, one respondent indicated that there can be problems with technology, especially the Microsoft games that come with computers as learners are tempted to play games and in most instances cannot resist the temptations. Below is figure 4.3, which indicates the learners' perceptions towards computers. It can be seen that generally the learners perceive the computers to be tools that contribute positively in Mathematics teaching-learning environment. In brief, figure 4.3 shows that about twenty learners who participated in the study have strong positive perception of educational technology usage towards Mathematics teaching and learning and the resources will:

- Improve learning;
- Make learning more interesting;
- Make their schoolwork easier;

It is only about five learners who perceived the educational technology as being a waste of money and can be used for playing games.

Figure 4.3 Learners' perceptions on ICTs usage



It can be deduced from 4.4.1 and 4.4.2 that both Mathematics educators and learners of Phusela Secondary School have a strong positive perception about educational technology usage in Mathematics teaching and learning.

4.5 Learners achievements' based on their written responses in line with the SOLO taxonomy.

The Mathematics content was divided into 3 sections for data collection effectiveness. The three sections are Algebra, Geometry and Trigonometry. The Algebra part was further subdivided into three more subsections; namely, number operations and relationships, algebraic patterns and functions and data handling. During data collection, it was discovered that only one grade had started with Geometry and Trigonometry and all the other grades had not started yet. Thus as all the learners had done Algebra only, learners responses in Algebra were analyzed.

A review checklist for learners' portfolios was designed to help in getting the learners achievements levels using the SOLO taxonomy. The checklist was divided into two sections; namely A and B. Section A focused on how close the learners' responses could be classified under a particular SOLO level, using a five point Likert scale. Section B focused on how often could the learners' responses be classified under a particular SOLO level. Section C was added on as a summary of learners written responses on particular sections as categorized under a particular SOLO level. The following criteria were used to classify learners' responses under a particular SOLO level.

Table 4.2 SOLO levels and the criteria for classifying learners' responses. Adapted from Biggs and Collis (1982)

SOLO level	Criteria
Pre-structural	Learners copied the questions/did not attempt questions which is an indication of not understanding of the question.
Uni-structural	Learners could not make comparisons to given results and one aspect of the question is mostly done
Multi-structural	Learners could not link together aspects in the questions
Relational	Learners could link together related aspects into a coherent structure
Extended abstract	Learners could extend their coherent structured knowledge into real life situation and other subjects other than Mathematics.

As there were a number of tasks that each learner had done on any of the mentioned sections, not of all them were analyzed. Only tasks seen to be requiring responses at the different SOLO levels were selected and analyzed.

The diagrams below indicate the learners' responses in relation to the SOLO level. The emphasis here is on classifying the learners' responses according to different levels of the Solo. The responses were also classified as junior secondary, which included grades 8-9 and senior secondary, which included grades 10 – 12. The first three diagrams represent responses of the junior secondary learners while the last three represent the responses of the senior secondary learners.

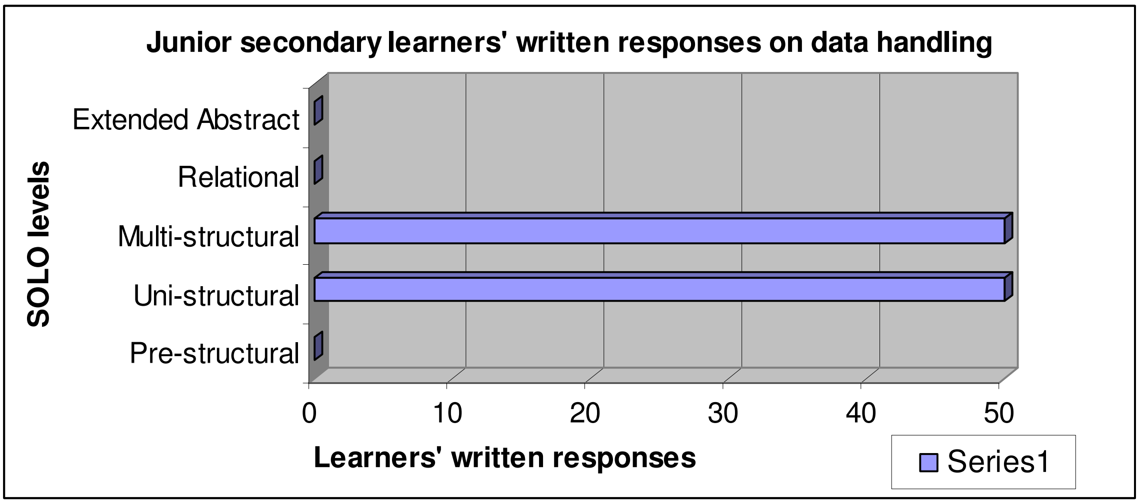
In the subsection data handling, there was no single response that could be classified under the following levels:

- Pre-structural: As learners showing no understanding of the tasks characterize this level, there was no single response that showed this kind of behavior. All learners got correct responses for this section but their responses could only be classified under Uni-structural and Multi-structural SOLO levels. From the responses it could be concluded that all the learners that participated in the study have a basic understanding of data handling.

- Relational: There were very few tasks that require the learners to response in this level. Even though they were there, none of the respondent could get the tasks correctly. There was an assignment given to grade 9 learners on probability requiring learners to come up with an explanation of an event. All the learners could not relate the explanation to the given scenario, which is a criterion for the SOLO relational level.
- Extended Abstract: None of the tasks that were given required learners to respond in this level. This might be a result of a number of many things. But the basis of them can be the educators' belief on the whole issue of Mathematics teaching and learning (Golafshani, 2002).

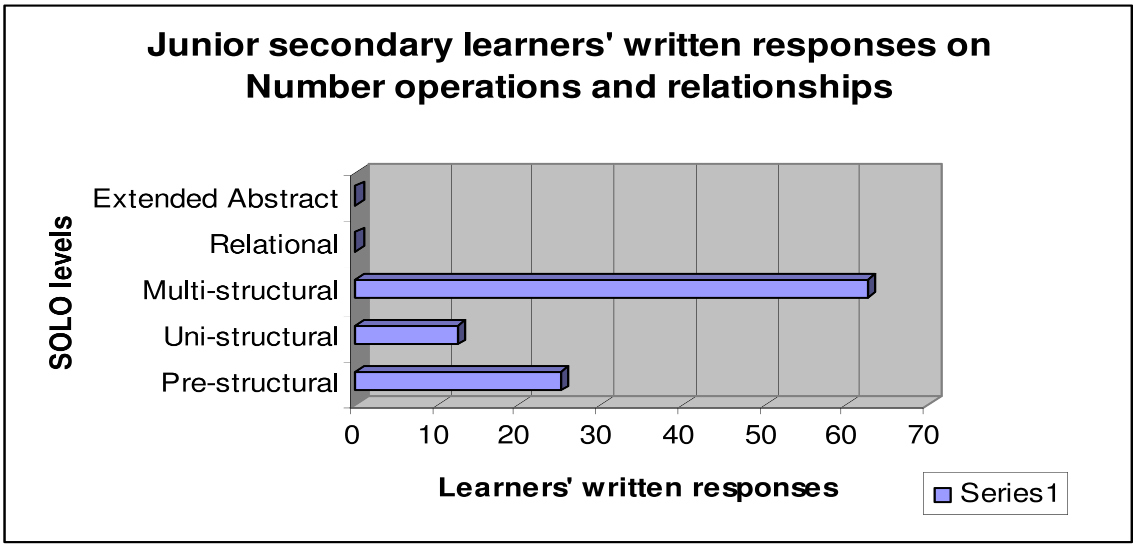
Figure 4.4 is a graphical representation of junior secondary learners' responses on the sub-section data handling based on the SOLO taxonomy. From the graph, it can be deduced that 49.9% of the learners' responses are classified as Uni-strucrural while 49,9% of the responses are classified as Multi-structural.

Figure 4.4: Junior secondary learners' written responses on data handling.



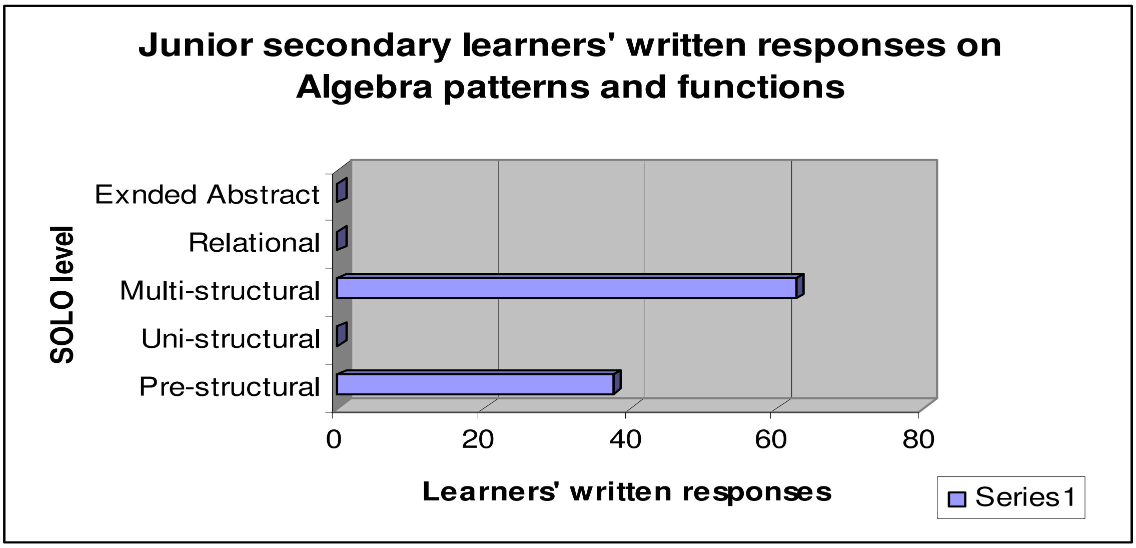
In the subsection number operations and relationships, there is no single response that can be classified under Relational and Extended Abstract levels. This is due to the fact that given tasks do not show or require learners to demonstrate operations in these levels. Figure 4.5 is a graphic representation of learners' responses in number operations and relationships. From the graph, it can be seen that 62% of the learners operate in Multi-structural level, 24% are on Pre-structural level and 12% are on Uni-structural level. Unlike the subsection data handling, number operations and relationships subsection responses range within the three levels. This is due to the fact that there are still learners that are operating in the Pre-structural level. Therefore, a sizeable number of learners do not have a basic understanding of number operations and relationships.

Figure 4.5: Junior secondary learners' written responses on Number operations and relationships.



In the subsection algebra patterns and functions, there are no learners' responses that can be classified under the Extended Abstract, Relational, and Uni-structural levels. From the given learners' portfolio, no task requires the learners to operate in Relational or Extended Abstract levels. However there was an abnormality as one level was skipped. According to the taxonomy the level are supposed to be chronological. But it can be deduced from figure 4.6 that there are almost 39% of learners that showed to be operating in the Pre-structural level none of the learners showed to be operating in the Uni-structural level whereas almost 61% of the learners showed operation in the Multi-structural level. This can be due to a number of factors. One contributing factor can be the timing of data collection as the data was collected in the first quarter of the schools' academic programme and not much was done on algebraic patterns and functions. Another contributing factor might be the fact that the grades 8 are coming from different primary schools and are starting with the section for the first time.

Figure 4.6: Junior secondary learners' written responses on Algebra patterns and functions

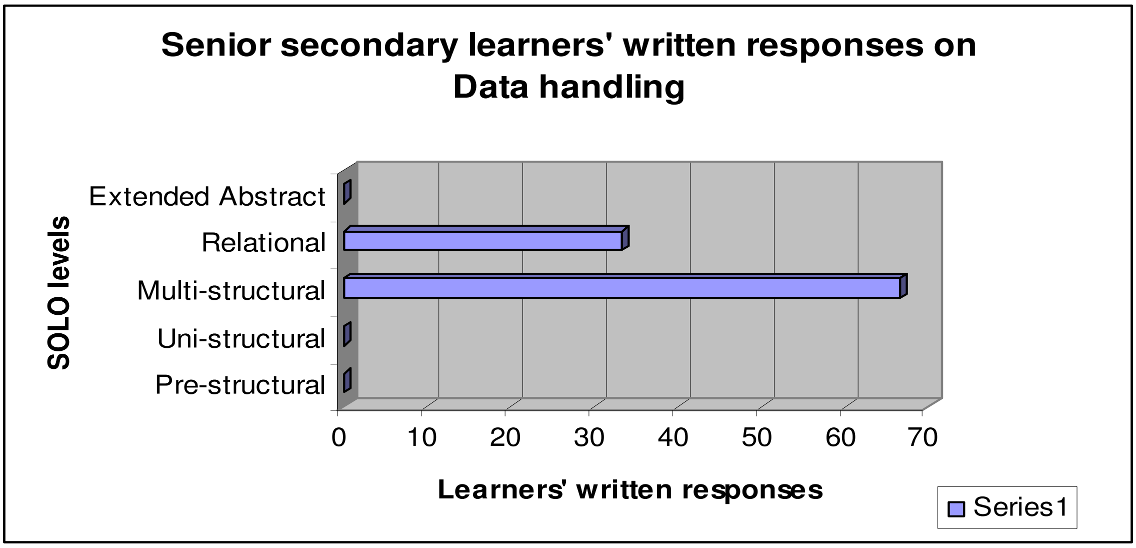


From the above graphical representations in Algebra, it can be concluded that junior secondary learners in Phusela Secondary School do show some problems with their operations in the subsection data handling. However they seem not to have many problems in number operations and relationships. In algebraic patterns and relationships no definitive conclusion can be made due to the abnormality that occurred.

The following last three graphical representations give a summary of the senior secondary learners' responses. For data handling in senior secondary learners, their responses ranged from multi-structural level to relational level. The majority of learners showed to be in the multi-structural level. Figure 4.7 is a representation of that for the senior secondary learners. It can be deduced from figure 4.7 that almost 67% of senior secondary learners' responses can be classified under Multi-structural level whereas almost 33% of learners' responses can be classified under Relational level. There are no learners' responses that can be classified under the following levels:

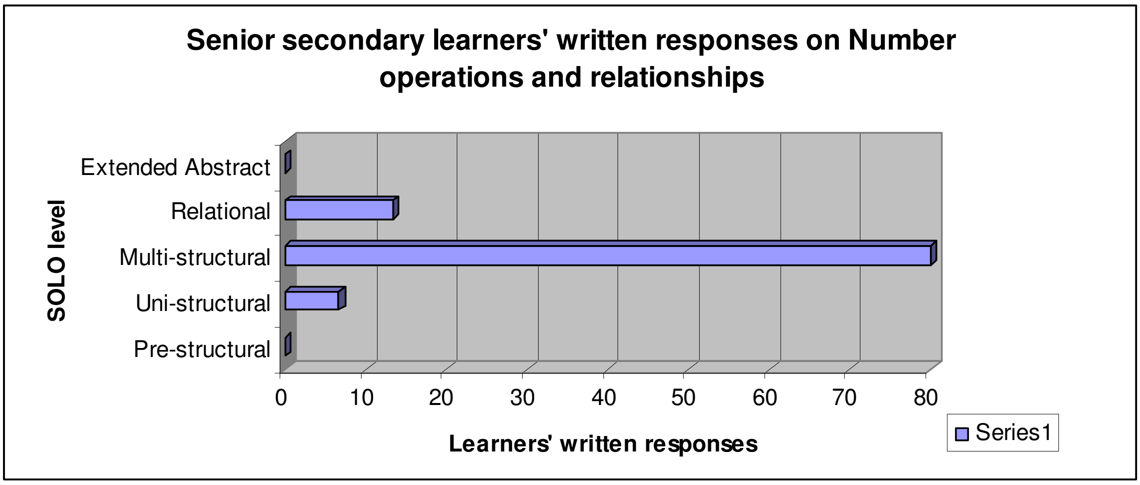
- Extended Abstract: there was no single task given to the learners that required this level of operation hence learners' responses cannot be expected.
- Uni-structural: from the given learners responses it was evident that all the learners' have moved beyond this level.
- Pre-structural: the evidence was the same as in Uni-structural.

Figure 4.7: Senior secondary learners' written responses on Data handling



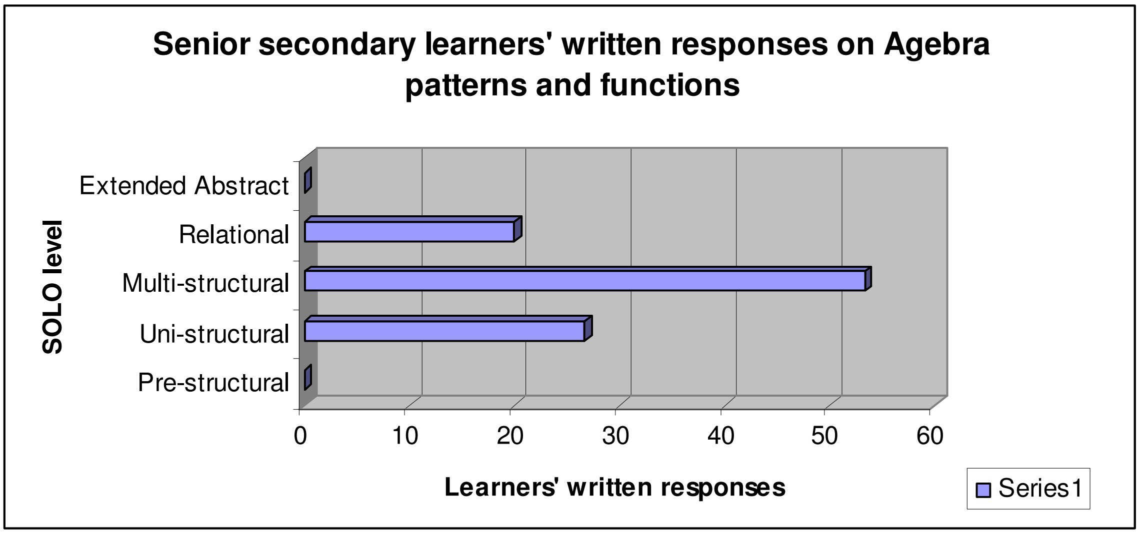
In the subsection number operations and relationships the learners' responses can be classified in a range of three levels. It can be seen from figure 4.8 that the responses can be classified as 7% Uni-structural, 79% as Multi-structural and 14% as Relational. No response can be classified as Extended abstract as learners' tasks did not involve that level of operation. Also, the responses show that learners have basic understanding of number operations and relations. When focusing on the two subsections, data handling and number operations and relationships like in the junior secondary, data handling range within two levels whereas number operations and relationships ranges within the three levels. On the contrary, the senior secondary learners' responses include a higher level, the Relational level and none of the responses is on the lowest level, the Pre-structural level.

Figure 4.8: Senior secondary learners' written responses on Number operations and relationships



In the subsection algebra patterns and functions, the learners' responses ranged within the three levels. It can be seen from figure 4.9 that 28% of the responses can be classified under Uni-structural level, 53% under Multi-structural and 19% under Relational. There is no single response that can be classified under Extended Abstract, as learners' tasks did not involve that level. From the learners' portfolios, it was evident that learners have a basic understanding of algebra patterns and functions. Hence no single response could be classified under Pre-structural level. Unlike the junior secondary learners' responses, no level was skipped.

Figure 4.9: Senior secondary learners' written responses on Algebra patterns and functions



The tasks that learners were engaged in were mostly demanding learners to exhibit Relational responses, especially the senior secondary tasks. The junior secondary tasks demonstrated more of operation on the Multi-structural level responses. There was no single task, which could be classified as needing the learners to give responses at an Extended abstract level. Looking at both the junior secondary and the senior secondary responses the following deductions can be made:

- The majority of responses can be classified under Multi-structural level.
- The junior secondary responses are a level lower than the senior secondary responses. That is, in junior secondary responses some responses have been classified under Pre-structural level, which is the lowest level whereas in senior secondary responses not even a single response could be classified under Pre-structural level for all the subsections. Thus the lowest level of responses classification in senior secondary is the Uni-structural. Similarly with the highest levels, for junior secondary responses is the Multi-structural level while for senior secondary is the Relational level.

4.6 Summary

From the findings, it can be concluded that computer technology is not used in Mathematics teaching and learning in Phusela Secondary School. Also the Phusela Secondary School computer laboratory is used very minimally and in most instances, it is used for other purposes other than for teaching and learning.

This chapter has shown that Phusela Secondary School educators and learners have very strong positive perceptions about the use of educational technology in Mathematics teaching and learning even though the educational technology resources are not utilized.

It can also be concluded from the findings that only a handful of educators attended training on educational technology integration in teaching and learning. There were also other problems that contributed to training not being done as planned. Due to financial constraints, online training could not be done and thus the face-to-face training was extended for a longer period.

4.7 Conclusion

The extent to which educational technology are used in a school is a result of a whole lot of factors such as educators' and learner' perceptions on educational technology tools, availability of these tools and the support provided by school management on preparation and usage of these tools. The next chapter is going to focus on that aspect basing its focus on the successes and failures of Thintana project at Phusela Secondary School on Mathematics teaching and learning. The successes and failures will be measured by learners' written responses in Mathematics using the Solo taxonomy.

CHAPTER 5 Conclusion and Recommendations

5.1 Introduction

The aim of the this study was to investigate the use of ICTs in Mathematics teaching and learning at Phusela Secondary School and compare the ICTs usage with learners' achievements in Mathematics. Even though there is some willingness on ICTs usage to improve teaching and learning at Phusela, there are a lot of many things that need to be looked into. In order to achieve this aim the answers to the following questions were needed.

- To what extent are ICTs used in Mathematics teaching and learning at Phusela secondary school?
- What are teachers' and learners' perceptions on the use of ICTs in Mathematics teaching and learning?
- How do learners' achievements in Mathematics compare to ICT tools usage in terms to Solo taxonomy?

5.2 Literature review

The review in Chapter 2 focused extensively on ICT usage in education and Mathematics in developed countries. The available literature on the use of ICT in rural schools in developing countries is very limited; hence the review in relation to this aspect was very limited.

Literature on Mathematics teaching and learning has shown that there is a general consensus on the need to enforce in our learners problem solving and high-order thinking skills in Mathematics so that they can be capacitated in pursuing successful careers

(Golafshani, 2002). Cooperation in Mathematics is identified as one of the ways in which problem solving and high- order thinking skills can be enforced in Mathematics learning (Adam & Hamm, 1996).

Uses of ICTs in education is not only restricted to developed countries. Also rural schools in developing countries are struggling in using ICTs despite the major challenges they are faced with (Castello, 2002 in Herselman, 2003; Pedro et al, 2004). It follows from the review in Chapter 2 that ICTs in teaching and learning are believed to support higher order thinking skills in learners through their own constructive thinking (Ping, Teo, Wong, Khine, Sing & Divaharan, 2003). In Mathematics ICTs help learners to apply problem solving, communication and mathematical reasoning skills, which are all part and parcel of higher order thinking skills (Jarret, 1998). Growth of ICT usage in Mathematics teaching and learning was mostly found in developed countries (Ruthven & Hennesey, 2002).

However as ICT tools are to be used by both the educators and learners it is important to find out what they think about these tools. From literature it was shown that educators that are using ICT tools do so because they see the importance of the tools making a positive contribution in their classroom practice (Sugar, Crawley & Fine, 2004).

From literature there is no conclusive evidence as to the extent to which the ICT tools contribute to learners' achievements (Kennewell, 2001). However there are contributing factors that need to be considered if ICT tools contribution to learners' achievements is to be realised.

5.3 Research design and methodology

As described in chapter 3 the study was a case study, which used mixed methods of research in one secondary school in Limpopo Province. The school was visited for the whole week for data collections. Participants were observed and hand written notes taken during observation, a tape recorder was used to capture data from the interview and a questionnaire was administered.

The use of a questionnaire for the learners was a bit complex as the questionnaire was written in English, and all learners were English second language speakers. Some of the questionnaires were filled with irrelevant information even though an explanation of the whole questionnaire was made in their home language for the whole group immediately after the distribution of the questionnaire. The reason might be the fact that the questionnaire was not filled immediately after the explanation. An interview would have been more convenient as there is provision for individual explanation during the process.

The next section (5.4) is a conclusion made based on the availability ICT tools because availability of the ICT tools has an influence on their usage in teaching and learning.

5.4 Availability of ICT resources at Phusela secondary school

Research conducted by Pelgrum (2001) in Ping et al (2003) from 26 countries found that the most frequent mentioned problem of successful and effective usage of ICT tools in teaching and learning was insufficient ICT resources that different institutions have. Table 4.1 indicates the learner computer ratio per grade of Phusela Secondary School. The grades 8 and 9 learner computer ratio as indicated in the table is 11:1 and 12:1 respectively. Due to this, cooperation on computers is not effective, as some learners do not even get chance of working on the computer for the whole session with the educator.

The unavailability of specific Mathematics software adds on to as another problem. As the school cannot afford the telephone bill even if they have free Internet access; therefore, the school needs some Mathematics software that would help the learners towards the development of higher order thinking skills in Mathematics. Access to a wider range of ICT tools and appropriate use supports learning. Lack of enough ICT tools makes it difficult for educators to accommodate the different learning styles and curriculum needs (Ping et al, 2003).

Another problem that relates to resources is the human resources. From the study it can be concluded that there are few educators who are skilled and who show some zeal in the use of the ICT tools in teaching and learning. This is supported by figure 4.2, which shows the training percentages of educators. All the educators do not have the computers at home. Thus access to computer is only limited to the school environment, which is not sufficient. Christensen (2002) indicates that,

> Educator's extent of experience with computer technology correlates positively with positive attitude towards computer use (p.430).

Therefore limited access to ICT tools will result in anxieties and fears of usage of the technology educators, which is also a contributing factor to resistance in using computers in teaching and learning (Gardner, Discenza & Dukes, 1993 in Christensen, 2002).

5.4.1 Recommendations

As Phusela Secondary School does not have enough ICT tools, it is imperative for planning of technology integration to consider that. Newhouse (2002) came up with three models of technology integration wherein each model has a different emphasis on the interaction between learners, computer systems and the educators. From this, it can be deduced that the number of learners that a school has and the number of resources available will have a bearing on the type of model to be used by a school in ICT tools usage in teaching and learning. Newhouse models are as follows:

- *Whole-class model* - The model is ideal in cases where there are not enough computers as one computer can be used for a large group of learners. However there need to be a data projector so that whatever is being demonstrated is clearly visible to all learners. According to Newhouse (2002) this model, "emphasises the teacher in control of any learner- computer interaction and therefore educator-centred". Phusela does not have a data projector thus this model cannot work at the school.

- *One-to-one model* – The model is ideal in instances where there are enough computers and the computer-learner ratio is 1:1. In this model individual learners are individually working on a computer. According to Newhouse (2002), this model," emphasises the learner- computer interaction and learner centred". From table 4.1, it is evident that this model can only be applied in grade 12. Learners should also be given time to work outside the normal teaching learning time. Therefore the computer laboratory should be made available. The educator has a space to move around and demonstrate to individual learners even though there is no data projector.
- *Group work model* - The model is ideal where there are not enough computers for individual learners. In this model, a group of learners work on one computer. According to Newhouse (2002), the emphasis is on learner-learner interaction with the computer. Accomplishment of tasks is group based. This is an ideal model for Mathematics learning as cooperation is at heart of effective Mathematics learning. The model is also suitable for Phusela Secondary School. In using the model they will be trying to make all their learners to have access to the little resources in a more meaningful and beneficial way. Also the educator has some space to move around and demonstrate to individual groups. Proper planning for this model is of utmost importance. Also the computer laboratory should be made available after normal teaching hours, as overlapping of time into after hours is unavoidable.

Therefore Phusela needs to use a combination of one-to-one model for a small and group work model for a larger group as indicated by table 4.1 of leaner computer ratio for their effective technology integration in Mathematics teaching and learning based on their available resources.

As Phusela cannot afford the Internet access, the school management should come up with a budget for resources like the educational software, which are going to support the development of higher order thinking skills. This will benefit the school, as the computers are installed generic software, which includes windows operating system and the Microsoft office application software.

For successful and effective ICT tools usage, educators' training is of utmost important (Coley, Cradler & Engel (1997); Silverstein et al (2000); Sandholtz (2001) in Ringstaff & Kelley (2002)). This will be very useful for educators to be in a position to purchase appropriate and relevant software, which will help in the development of higher order thinking skills in Mathematics. Ringstaff & Kelley further indicate that the more time the training of educators, the more effective ICT tools usage by educators. Training should start with basic ICT tools skills and then when educators have developed confidence move on to the pedagogical use of ICT tools. Educators' ICT tools usage impact directly on learners ICT tools usage. However training alone is not sufficient. There should be ongoing support that will help educators to deal with the challenges that they are faced with in their endeavour in ICT tools usage.

In-house training will be the convenient training approach that Phusela can take. As the school does not have enough money for training of educators, trained educators can act as facilitators and continue training their untrained educators because SNSA training cycle is completed. Also from research, it is noted that educators that are willing and motivated to integrate technology in teaching and learning can serve as models and mentors for their reluctant colleagues (Ringstaff & Kelley, 2002). For the efficiency and effectiveness of this process, it should be part and parcel of the whole activities plan of Phusela and let the school have a policy on training of educators on educational technology usage. In the policy, there should be clearly defined strategies on the development of educational technology competencies of both learners and educators and the educational technology standards for both educators and learners which should include both the pedagogical and technical skills that satisfy the needs of rural schools like Phusela (Ping et al, 2003).

Ping et al, (2003), see another important aspect in effective ICT tools usage being the availability of a technical support assistant who will deal with trouble-shooting technology related problems. The EDN modules do not have that in their modules. Thus it implies that Phusela should employ somebody with those needed expertise, which is unlikely possible, as funds do not allow. Therefore, there needs to be a consideration of another addition to EDN modules, which focus on the technical aspect of the technology environment.

5.5 Usage of educational technology in Mathematics teaching and learning

Usage of ICT tools in education should be informed by the benefits that it will provide to the education system. A research conducted by Eadie (2001) in New Zealand has found that the following reasons were given as delays for widespread of ICT tools in Mathematics teaching and learning:

- Educators lack of ICT tools skills;
- Insufficient time for planning and learning of the skills effectively;
- Examination oriented learning which result in learners anxiety;
- Insufficient resources;
- Lack of proper planning;
- Resistance to change; and
- Inability to make a link between ICT tools and the curriculum.

Newhouse (2002) also agrees with Eadie but went on further and mentions the following aspects:

- Lack of experience of educators; and

- Allowing the ICT tools to dictate what need to be done and not being guided by aims and of teaching and learning.

However an inspection in the U.K by Brown et al (2002) has found that there is limited use of ICT tools in Mathematics teaching and learning. According to Brown et al this is due to the following reasons:

- Lack of support and/ or training;
- Lack of funding;
- Doubts about the benefits of the use of ICT tools in teaching and learning; and
- Lack of knowledge of relevant available resources.

All these above mentioned aspects by Eadie, Newhouse and Brown et al support the conditions at Phusela Secondary School. Figure 4.2 shows percentages of trained educators for the use of ICT tools in Mathematics teaching and learning and supports one of the reasons cited as stumbling blocks for effective ICT tools usage. Also the lack of a policy or guidelines on ICT usage implementation supports one of the reasons that make educators resist the use of ICT tools in their teaching learning scenarios. Without a policy, it is difficult for the schools to come up with logical and effective plans of how to use educational technology in the classroom environment.

Another contributing factor that can be regarded as a stumbling block for the effective ICT usage implementation is the perception of both the educators and learners about the use of ICT tools in Mathematics teaching and learning. Both educators and learners have a strong positive perception about the potentials of ICT tools in Mathematics teaching and learning. However there are still few learners and an educator who have no extensive awareness of the roles of ICT tools in Mathematics teaching and learning. For example, learners think that when playing mathematical computer games no learning is taking place. Also some educators believe the ICT tools will ultimately replace them. It is through the educators' facilitation that learners acquire the Mathematical skills, and the technology can only help learners to develop and enhance those acquired skills to a more advanced level.

5.5.1 Recommendations

From the mentioned stumbling blocks of Phusela it is evident that not all the stake-holders were involved in the planning of technology integration of the school. Thus it is never too late for the school to involve all the stakeholders for the better development of clearly articulated standards and goals of ICT tools usage in teaching and learning. A research done by ACOT has found that successful ICT tools into the classroom depends also on the level of support that educators receive from stake-holders, especially the school and district management (Sandholtz, Ringstaff and Dwyer, 1997 in Ringstaff & Kelley, 2002). This is evident in Phusela Secondary School where the educators indicated large classes is one of the major stumbling blocks for using the ICT tools in Mathematics teaching and learning. However there is no mechanism in place by the school to try and address this problem. Thus involvement of interested parties is of paramount importance for successful and effective technology integration.

Educators need to articulate how the use of ICT tools fit into the Mathematics curriculum and Instructional framework. Ping et al (2003) see correct and appropriate classroom practice helping educators to acquaint themselves more with the effective and efficient use of ICT tools in the teaching and learning environment. They further mention the correct and appropriate classroom practice as aspects like:

- Coming up with correct and appropriate procedures for working with ICT tools in a group situation, which is unavoidable at Phusela secondary school due to learner-computer ratio;
- Designing clearly defined roles of learners in an ICT- based learning environment so as to avoid unproductive and chaotic learning environment; and

- Coming up with general rules that will help the learners to stay focused on their tasks, like prohibiting them from playing computer games which are not related to their activities while in the computer laboratory.

These are aspects that need to be considered by the Phusela Secondary School educators when planning for ICT usage in their classrooms. These will result in learners being more task-oriented; reflective and more likely to be engaged in higher order thinking skills (Ping et al, 2003). Educators should be willing to learn from learners not be threatened in relinquishing their roles as experts (Ringstaff, Sandholtz & Dwyer, 1991).

Adequate and continued support from the SNSA mentors and trainers will help educators to focus on Mathematics outcomes, which will guide their technology use in Mathematics. The support should continue even after the training completion as, presently, there is no provision for that; therefore, educators find themselves in a more vulnerable situation in as far as the ICT tools usage is concerned.

The initial training modules concentrated more on the Internet. Out of the seven topics four were more on the Internet, which is not really relevant for rural schools like Phusela as maintenance of the Internet is far above the school affordance. The revised Educators Network (EDN) module, which was not used for Thintana training has different learning pathways and considers the different South African situations. That is, it has topics that are suitable for urban self-sufficient schools and those that are suitable for rural impoverished schools. Thus trained educators could use the revised EDN module for training their colleagues. It is in the revised EDN module that there is a topic that deals specifically with ICT tools and Mathematics, which will be more informative and relevant for Mathematics educators. Therefore Mathematics educators should be compelled to choose this topic in their choices of the different topics.

5.6 Perceptions about ICT tools usage in Mathematics teaching and learning

The educators' belief system about ICT tools usage in teaching is important as, it will influence how educators will use these tools in the classroom (Drenoyianni & Sealwood, 1998). Drenoyianni and Sealwood further indicate that the educators' knowledge of how learning occurs in a mediated learning environment reinforces this. Cope & Ward (2002) add that perception of the ICT tools, as tools that enhance deep learning will make educators to use them for deep learning in the classroom.

Parr (1999) in Cope & Ward (2002) found that positive perceptions of learners in ICT tools influence the usage of these tools among learners. Bennet and Lockyer (1999) also add that positive perception has an impact on learners' motivation in using these tools, which imply that learners' acquaintance with these tools will be fast and quick and be more confident.

Both the educators' and learners' perceptions about ICT tools usage at Phusela Secondary School were positive as evidenced in figure 4.3 and 4.4.

5.6.1 Recommendations

Based on figures 4.3 and 4.4, the educators at Phusela Secondary School should use this positive perception as their strength in the development of policy in the implementation of the ICT tools in Mathematics teaching and learning. This is one of the strong points that the community of Phusela need for motivating them even though they are faced by other challenges.

5.7 Learners' achievement in Mathematics as they relate to SOLO taxonomy

From the findings in chapter 4, Mathematics learners' achievements can be summarized by table 5.1, which follows from data taken from figures 4.4 – 4.9.

Table 5.1: Phusela Secondary School Mathematics learners' achievements

Learners level of classification	Mathematics Sections	Demonstrated Solo levels
Junior Secondary Learners	Data Handling	Multi-structural
	Number Operations	Multi-structural
	Algebraic Patterns	Multi-structural
Senior Secondary Learners	Data Handling	Multi-structural
	Number Operations	Multi-structural
	Algebraic Patterns	Multi-structural

According to Biggs & Collis (1982), there exists a correspondence between the learners' age and their level of response. Based on this relationship, the following conclusions can be made for mathematics in relation to the SOLO taxonomy:

- Uni-structural responses are to be generally found in the early years of elementary Mathematics.
- Multi-structural responses are to be generally found in the later years of elementary Mathematics.
- Relational responses are to be generally found in the junior secondary.
- Extended abstract responses are to be generally found in senior secondary.

Table 5.2 is a relationship of learners chronological age with the SOLO level descriptors based on the mentioned correspondence between learners' age and their level of response.

Table 5.2: Relationship of learners chronological age with Solo level descriptors

Learners' age in years	Expected SOLO level descriptor
4 – 6	Pre-structural
7 – 9	Uni-structural
10 – 12	Multi-structural
13 – 15	Relational
16 +	Extended Abstract

Comparing tables 5.1 and 5.2, it is evident that Phusela secondary learners are performing far much below their expected level of competencies according to SOLO taxonomy. According to Campbell (2004), it was found in Hawaii by the Department of Education that higher order thinking skills can be developed when learners are able to solve problems and develop solutions using the ICT tools. Campbell further indicated that the skills could be enhanced if learners are given opportunities to work cooperatively with the help of these tools.

A research conducted by Acelajado (2003) has found that one of the factors of poor performance of learners in Mathematics is attributed to Mathematics anxiety. It is through the use of technology that learners develop confidence in Mathematics and their anxious feeling is highly reduced. Phusela secondary school learners still have Mathematics anxiety which is an indication that ICT tools are very little or not used for teaching and learning of Mathematics. A study by Kmitta and Davis (2004) has confirmed that the appropriate use of ICT tools has positive effects on learners' achievements. However they went on further to indicate that ICT tools are no quick fix solutions to problems in education. An improvement of higher order mathematical thinking was attributed to learners' use of simulation and support software (Wenglinsky, 1998 in Newhouse, 2003). Therefore the ICT tools need to be used so that learners can develop basic mathematics skills as well as higher order thinking skills. That is a culture of thinking in Mathematics that should be developed and enhanced (Ping et al, 2003).

5.7.1 Recommendations

Wenglinsky (1998) acknowledges that the use of ICT tools has an effect on learners' achievements, but the effect can be seen in the way the technology is used and not the frequency in usage. It is thus important for educators in Phusela to be aware of the mathematical software that help in the development of higher order thinking skills. They need to have knowledge on evaluation of software and be able to design the activities that involve higher order thinking skills. That is, their selected programs should involve problem solving and information processing. The educators activities in class should be more learner centred while the ICT tools are utilised, and a provision for cooperation learning be done (Campbell, 2004).

5.8 Recommendations for further studies

Research on a larger scale is needed to see if the findings of this investigation can be generalized to all the Thintana pilot project schools in South Africa. The following should be focused:

- The existence of a relationship between ICT tools usage and ICT policy;
- Effective training model of ICT tools usage in teaching and learning; and
- Whether the recommendations made in this chapter will be feasible to all the Thintana pilot project schools.

5.9 Conclusion

This chapter concludes an investigation of how ICT tools are used in rural South African secondary schools. The study investigated the use of ICT tools in Mathematics teaching and learning and how does this impact on learners' achievements. The Solo taxonomy was used as a measure of learners' achievements in Mathematics. As can be seen from the study, ICT tools are not used in Mathematics teaching and learning. There are lot of contributing factors to this condition at Phusela Secondary School like:

- The absence of guidelines or policy on the use of ICT tools in the whole school;
- Inadequate training of educators on ICT tools usage in teaching and learning; and
- Lack of relevant ICT tools for rural schools.

The learners' achievements also bear a testimony to this fact that ICT tools are not used in Mathematics teaching and learning.

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Appendix A

Observation checklist for Educators' workbook

1. Which of the following do educators in their workbooks use?

   ☐ Word processing

   ☐ Spreadsheet

   ☐ Power point

   ☐ Other (Specify) ______________________________

   ____

2. Do educators use technology in the creation of their class lists?

   ☐ Yes ☐ No

   Explain ______________________________________

   ____

   ____

3. Do educators use technology in the creation of their record books?

   ☐ Yes ☐ No

   Explain ______________________________________

   ____

   ____

Appendix B

OBSERVATION CHECKLIST FOR LEARNERS PORTFOLIO

This checklist is focused on the levels of the Solo taxonomy looking at the learners reasoning within written responses to show their understanding of mathematics.

A. The following will be used

1= Strongly Agree
2= Agree
3= Somewhat Agree
4= Disagree
5= Strongly disagree

1. The learners had to think hard in the given tasks					
2. The tasks concentrated on one idea at a time					
3. The tasks concentrated on a few ideas at a time					
4. The tasks concentrated on many ideas at time					
5. The tasks linked with the previous knowledge					
6. The tasks required learners to relate many ideas					
7. The tasks consisted of some open-ended problems					
8. The tasks consisted of learners responses placed into given structures					
9. Do tasks require many detailed facts/concepts?					
10. Do tasks emphasize reproduction of basic facts, details or concepts?					
11. Do tasks require learners to synthesize or integrate concepts?					
12. Do task require learners to relate facts, concepts or ideas?					
13. Do tasks require learners to come up with generalization and relate these in a broader sense?					
14. Do tasks relate to the use of Mathematics in everyday life?					

B. The following will be used

1= Not at all

2= About half the time

3= Frequently

4= Nearly all the time

1. There may have been preliminary preparation, but the tasks are not attacked in appropriate ways				
2. One aspect of the tasks is performed serially, however there is no relationship to other factors or ideas.				
3. Two or more aspects of the tasks are performed serially with limited inter-relationships to other ideas. The learner has limited understanding of how concepts or ideas fit together				
4. Several aspects are integrated so that the whole has a coherent structure and meaning and of itself.				
5. The coherent whole is extended to abstract principles of generalization underlying what is being taught.				

C. Which Solo level best describes the learners written responses?

Mathematics topics/section	Solo Taxonomy levels				
	Pre-stuctural responses	Uni-structural responses	Multi-structural responses	Relational responsible	Extended Abstract responses
Geometry					
Data handling					
Number operations and relationships					

Algebra, patterns and function					
Trigonometry					
Measurement					

4. Are learners' records managed by technology?

☐ Yes ☐ No

Explain ____
____
____

5. Do assessment programs incorporate technology applications?

☐ Yes ☐ No

Explain ____
____
____

6. Is influence of technology on learning prevalent?

☐ Yes ☐ No

Explain ____
____
____

7. Are the learning outcomes the guiding factor in technology integration?

☐ Yes ☐ No

Explain ____

____

____

Appendix C

INTERVIEW SCHEDULE FOR THE EDUCATOR

Below follow the interview questions focused during the interview with the educators on using technology in the class.

1. How did you introduce the ICT to the learners?
2. What adjustments, if any did you make to your original plans for using the technology once you started teaching?
3. In what way did the technology
    - help your teaching?
    - Hinder your teaching?
4. How did the learners respond to the technology?
5. Do you think that the technology can help learners to learn? If so how can it help the learners to learn?
6. Have you learnt anything new by using the technology in your class?
7. Does the technology help you cover the key mathematics concepts in the syllabus?
8. Do you need any further support to use the material? If so, what support do you need?

Appendix D

INTERVIEW SCHEDULE FOR THE LEARNERS

Below follow the interview questions focused during the interview with the learners on using technology in the class.

1. What difference did the technology bring about in learning?
2. Is the technology helping you to learn mathematics concepts better?
3. How is the technology
    - helping you to learn?
    - Hindering you to learn?
4. What do you enjoy doing with technology in learning?
5. What do you actually do with technology in the class?
6. What do you see as the importance of technology in learning?

Appendix E

EDUCATORS' QUESTIONNAIRE

A: SCHOOL RESOURCES

1. Name of school ______________________________________
2. School Address ____

   ____
3. School phone no. ____________________________
4. How many computers does your school have for teaching and learning?
5. How many computes did you have before the introduction of Thintana i-learn project?
6. How did your school acquire the computers before the Thintana i-learn project?

   ____

   ____

   ____

   ____

   ____
7. Do you have access to the internet?

   Yes ☐ No ☐

   If yes, how many teaching and learning computers are connected?

8. Which of the following technologies exist in your school for teaching and learning and how did you get them?

   ☐ TV(s)

   ☐ Video machine(s)

☐ Overhead projector(s)

☐ Calculators

9. Which of the following technologies existed before Thintana i-learn project in your school and how did you get them?

☐ TV(s)

☐ Video machine(s)

☐ Overhead projector(s)

☐ Calculators

B. TRAINING OF EDUCATORS

9. How long have you been teaching? ____________
10. What grade level have you been teaching?______________________________
11. Do you have a computer at home?

Yes ☐ No ☐

If yes, is it connected to the internet?

12. Have you been trained for Thintana i-learn project?

Yes ☐ No ☐

13. Did you have any computer skill before the training?

Yes ☐ No ☐

If yes, please specify ________________________________

____

____

14. Which of the following were you trained in?

☐ Word processing

☐ Spreadsheet

☐ Presentation skills

☐ Using the internet to find information

☐ Using web resources

☐ Designing WebPages

☐ Databases

☐ Information skills

☐ Other training, please specify _______________________

15. Were you trained on different computer systems?

Yes ☐ No ☐

If yes, please name the system and explain each briefly in the provided table

System	Explanation

16. How many days did you have a face-to-face training?
17. How many hours per day did you spent at the training?
18. How long was the distance training?
19. What kind of support did you get for the distance training?____

____

____

____

20. How often did you have computer practice after training? ____________

____

21. Were you trained in technical support for your school?

Yes ☐ No ☐

If no, why not? ____

____

22. Do you use information from the internet for teaching purposes?

Yes ☐ No ☐

23. Do you see any barriers to your use of technology?

Yes ☐ No ☐

If yes, please describe them ________________________________

____

____

____

24. Which aspect(s) of Thintana training program did you find most satisfactory?

____

____

____

25. Which aspect(s) of Thintana training program did you find most unsatisfactory?

____

____

____

____

____

26. Which further training will you recommend for Thintana programme?

____

____

____

____

____

C. USE OF EDUCATIONAL TECHNOLOGY IN THE CLASSROOM

27. How often do you use each of the following with your learners?

	Daily	Weekly	Monthly	Never	Less than four times a year
Word processing					
Spreadsheets					
Databases					
Presentation Software					
Email					
World Wide Web for research and information					
Drill and Practice programs					
Tutorial programs					
Simulation programs					
Games					
Overhead projector					
T.V,Video					
Calculators					
Other, please specify					

28. How do you use ICT’s in your classes?

☐ To support individual learning

☐ To support co-operative learning

☐ To organize and store information

☐ To collect data and perform measurement

☐ To manipulate/analyze/interpret data

☐ To communicate information as the result of investigation

☐ To create visual display of data/information (e.g. charts, graphs, maps)

☐ To plan, draft, proofread, revise and publish written text

☐ To perform calculations

☐ To create models or simulation

☐ For remediation of basic skills

☐ Other, please specify ____

____

____

29. How do you use Internet in your class(es)

☐ Gather information from a variety of sources

☐ Communicate with others outside the school

☐ Other, please specify ____

____

____

D. TEACHERS PERCEPTIONS ABOUT EDUCATON TECHNOLOGY

Choose only one in each.

1 = Strongly Disagree (SD)
2 = Disagree (D)
3 = Undecided (U)
4 = Agree (A)
5 = Strongly Agree (SA)

30. Educational technologies engages learners attention and motivate them					
31.Educational technologies improves learners' test and exams results					
32. Educational technology stimulate learners curiosity					
33. Educational technologies encourage learners to develop their problem solving strategies					
34. Educational technology provide models and images which aid learners in concept formation					
35. Educational technologies improve the teachers efficiency					
36. Educational technologies reduce the teachers administration burden					
37. Educational technologies provide better records of learners' progress					
38. Educational technologies improve teachers' approach and understanding of teaching					
39. Educational technologies create a platform for teachers to communicate with other teachers sharing common problems					
40. Educational technologies support co-operative learning					
41. Educational technologies support individualized learning					
42. The internet has proved to be a useful source of ideas and information for teachers					
43. Using educational technology is an important aspect of teachers' work					
44. Technology assisted instruction is more effective than the traditional method of instruction.					
45. Computers will gradually replace teachers					

E. TEACHERS' EDUCATIONAL TECHNOLOGY COMPETENCY

Use the scale provided in (D) and choose only one in each

45. I feel competent using application programs to develop lesson plans					
46. I feel competent using e-mails to communicate with colleagues					
48. I feel competent using the World Wide Web to find educational resources					
49. I feel competent constructing and implementing project-based learning lessons in which learners use a range of information technologies					
50. I feel competent to help learners to solve problems, accomplish tasks and use higher order thinking skills in an information technology environment					
51. I feel competent about teaching learners appropriate information					
Technology skills and knowledge					
52. I feel competent working with learners in various information technology environment					

Appendix F

LEARNERS QUESTIONNAIRE

1. School Name ____
2. Learner's gr ______ Learner's Age & Sex ________________
3. Do you have a computer at home?

☐ Yes ☐ No

If yes, Is the computer connected to the Internet?

☐ Yes ☐ No

4. Do you use your computer at home for you schoolwork?

☐ Yes ☐ No

If yes, please explain what type ______________________________________

____

____

Please complete the following placing a tick in one of the five boxes next to each Statement.

5. It is important that I use computers in my learning because it make my school work easy	Strongly Disagree	Disagree	Agree	Strongly Agree	Undecided
6. Using computers at school improves my learning					
7. When I use computers at they make learning more interesting					
8. I make good use of email at school					
9. I make good use of internet at school					
10. I can get access to computers at school whenever I need to					
11. I use computer at school to do the following:	Daily	Weekly	Monthly	Less than four times a year	Never
Writing or publishing					
Email					
World wide web					
Mathematics learning					
Playing games					

Other					
12. I use computers at home to do the following:	Daily	Weekly	Monthly	Less than four times a year	Never
Writing or publishing					
Email					
World wide web					
Mathematics learning					
Playing games					
Other					

Appendix G

Request permission letter to the Circuit Manager

Enq: Moila M.M
Cell: 083 667 4856

Box 27484
SUNNYSIDE
0132
2nd February 2004

The Circuit Manager
Thabina Circuit Office
Department of Education
Private bag X1411
LENYENYE
0857

Sir

Request for permission to do data collection in one of your schools: Phusela Secondary

1. With reference to the above matter kindly consider my request to collect data at the above-mentioned school.
2. The data is part of my research work towards an M.Ed. degree, I'm presently studying with University of Pretoria.
3. The expected participants are supposed to be all Mathematics educators and a sample of learners from the school
4. Your cooperation is always appreciated.

Yours Faithfully
Moila M.M (Ms)

Appendix H

Request permission letter to the school

Enq: Moila M.M
Cell: 083 667 4856

Box 27484
SUNNYSIDE
0132
2nd February 2004

The Principal
Phusela Secondary School
Box 64
LENYENYE
0857

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 part of my research work towards an M.Ed degree I'm presently studying with University of Pretoria.
3. I intend coming to your school from the 10th to the 14th May 2004 and would like to spend the whole week at your school.
4. Attached is a request for permission letter that was written to the Circuit manager Mr Mbhalati T.
5. Your cooperation is always appreciated.

Yours Faithfully
Moila M.M (Ms)

Appendix I

Observation checklist for classroom interaction

1. Physical features

1.1 How big is the computer lab?

1.2 How is the lighting in the lab?

1.3 How are computers positioned in the lab?

1.4 How is ventilation in the lab?

1.5 What is the learners sitting arrangements?

1.6 How are the computers' conditions?(Clean, dusty, etc)

1.7 No of operational computers.

1.8 No of computers connected to a printer and/ internet.

1.9 No of Maths software programs available.

2. Use of ICTs in class

2.1 Does the educator?

(a) Use media and technology that are specific to the content area
(b) Include integrated teaching and learning experiences using Internet and other technologies
(c) Provide opportunities for learners to use the Internet as a source of information
(d) Have skills in the selection of appropriate Internet sites and use of advanced search engines.
(e) Integrate the Internet to simulate real world problems.
(f) Create group projects using computers and Maths programs.
(g) Allow learners to discover, share and create things using computers and Maths programs.
(h) Give provision for learners' feedback presentations in their projects using the computers.

Appendix J

Limpopo

PROVINCIAL GOVERNMENT

SHILUVANE / KHUJWANA CIRCUITS

POLICE STATION STREET
LENYENYE - 0857
TEL. NO (015 355 3401)

PRIVATE BAG X1411
LENYEYE - 0857
FAX NO. (015 355 4782)

REF : 23287072
ENQ : Mbalati T

April, 2004

The Head of Department
Department of Curriculum Studies
Faculty of Education
University of Pretoria
PRETORIA
0001

PERMISSION TO CONDUCT A RESEARCH AT PHUSELA SECONDARY SCHOOL

1. The matter alluded to above refers.
2. Permission is hereby granted that Moila MM conducts a study at Phusela Secondary School with the intention to complete her Masters Degree in Computer Integrated studies.
3. However, bear in mind that all processes and activities that shall take place must not interfere with the normal smooth running of the school programme.

....
CIRCUIT MANAGER
KHUJWANA & SHILUVANA
/tim

DEPARTMENT OF EDUCATION
MOPANI DISTRICT