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LEVELS OF INFORMATION AND COMMUNICATION TECHNOLOGY INTEGRATION IN MATHEMATICS TEACHING AND LEARNING AT JUNIOR SECONDARY SCHOOL IN MAHALAPYE REGION

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Abstract

This study aims at finding out the levels of ICT deployment in Mathematics teaching and learning at Junior Secondary Schools in Mahalapye region, with the specific intent to explore the media used and how they are utilised by teachers during teaching and learning of mathematics. This was upon realisation that times are changing and ICT is at the forefront of various developments worldwide, hence the intention to carry out a study that draws a relation between the researcher's field of work, Mathematics teaching and ICT.

The study shall use a content analysis approach for data collection with interview, questionnaire and observations as the key data collection instruments. The population of the study will include all Mathematics teachers in Junior Secondary Schools in Mahalapye region. The study sample shall comprise of ten Mathematics teachers drawn from five Junior Secondary Schools in Mahalapye region. The ten teachers shall be purposively sampled. The collected data will be analysed using various techniques such as SPSS and content analysis techniques. The findings will be used to draw a conclusion on how and which media are deployed in the teaching and learning of mathematics and draw some recommendations on how ICT can be integrated in the teaching and learning of mathematics.

Abbreviations

BEC	Botswana Examination Council
BECTA	British Educational Communications and Technology Agency
BGCSE	Botswana General Certificate of Secondary Education
ICT	Information Communication Technology
JCE	Junior Certificate Examinations
MAB	Mathematics Association Botswana
NAEP	National Assessment of Educational Progress
NCTM	National Council of Teachers of Mathematics
QDA	Qualitative Data Analysis
SMASSE	Strengthening of Mathematics and Science in Secondary Education
SPSS	Statistical Package for Social Sciences
TIMSS	Trend in Mathematics and Science Study
WWW	World Wide Web
UNESCO	United Nations Educational, Scientific Cultural Organisation
TIMSS	Trends in International Mathematics and Science Study
LMTF	Learning Metrics Task Force
MDG	Millennium Development Goals
MoE	Ministry of Education
UIS	UNESCO Institute for Statistics

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Chapter 1

1.0 Introduction

This study aims to investigate the levels of ICT integration in Mathematics teaching and learning and the common media teachers use in their teaching. The use of ICT being at the forefront of economic and social development across the globe prompted the researcher to conduct the study.

1.1 Background of the Study

Technology has become the knowledge transfer highway in most countries. Nowadays, technology integration has gone through innovations and transformed our societies, totally changing the way people think, work and live (Grabe, 2007) cited in (Ghavifekr and Rosdy, 2015). Computers have become a common tool for communication, text processing, and many other activities, including different media, audio, graphics, videos, and virtual reality. The establishment of the internet and its increased accessibility has opened a whole new digital world. Children are exposed to new information and computer technology at school and also at home. Many children today have computers at home and have access to the internet. The children use computers and technology for entertainment, communication and education in their routine activities (Curri, 2012). Computer literacy is regarded as a vital skill in occupational activities because people widely use technology in business, economics and many other professions (Curri, 2012).

In that regard, teachers are considered key players in using ICT in their daily classrooms in relation to preparing students for the current digital era hence ICT can provide a dynamic and proactive teaching-learning environment (Arnseth and Hatlevik, 2012).

Using technology in education contributes a lot in the pedagogical aspects whereby the application of ICT will cause effective learning with the help and support from ICT elements and components (Jamieson-Proctor,Albion, Finger, Cavanagh, Fitzgerald, Bond and Grimbeek, 2013). Almost all subjects starting with Mathematics, Science, Languages, Arts and Humanistic and other main fields can be learned more effectively through technology-based tools and

equipment. ICT further provides help and complementary support for both teachers and students for effective learning with the use of computers as learning aids (Jorge, Gutierrez, Garcia, Jorge and Diaz, 2003).

Given the importance technology plays in our lives, schools now have a responsibility to integrate it into teaching and learning to prepare students for 21st Century skills and careers (Cakir, 2012; Luterberbach and Brown, 2011).

Therefore, schools are expected to promote the acquisition of knowledge and skills by the use of new technologies to ensure efficient, continuous and lifelong learning (Mathipa and Mukhari, 2014).

Computers and technology do not act as replacing tools for quality teachers, but they are taken as add-on supplements required for better teaching and learning hence learning can take place even if the teachers and students are physically apart (Young, 2003, cited in Ghavifekr and Rosdy, 2015).

Cuban (2001) argues that students need to have adaptive skills in using ICT to compete for future jobs with their counterparts globally. Implementing ICT in education was meant to transform the teaching and learning process from the traditional instructional teacher-centred endeavour to a learner-centred approach with active participation of the learner (Voogt, 2008; Voogt and Pelgrum, 2005; Voogt 2010; Voogt et al., 2013). Mishra and Koehler (2006) state that ICT can support the content and pedagogic knowledge of the teacher for effective educational practices in the classroom. Despite the massive investment in integrating ICT in many secondary schools, the practical use of these ICT tools by teachers remain in a preliminary stage with little significance in the educational outcome (Howie, 2010).

Introducing computer science in Senior Secondary Schools and computer awareness in Junior Secondary Schools as optional subjects was a way of equipping teachers and students with the technological knowledge of using ICT in Botswana education system. However, the proper integration of ICT in the teaching and learning process in Botswana is still at its preliminary stage. Some teachers still actively resist the use of modern technology in daily instruction. They

are more comfortable with the traditional instructional method of teaching and see no relevance in the use of ICT (Ndibalema, 2014). Different studies have found that ICTs are tools which encourage and support independent learning (Cuban 2001; Grimes and Warschauer, 2010; Lowther, Inan, Ross, and Strahl, 2012; Warschauer, 2008).

ICT in education can enhance a learning environment for learners and act as a powerful tool to supplement teachers' classroom instructions (Jhuree, 2005), cited in (Kennah, 2016).

Gibson et al. (2014) state that increasing the implementation of computers in schools does not ensure effective use of the tools by teachers to improve student outcome. As a result, teachers were using computers to prepare for lessons rather than for direct instructional use (Cuban, 2001).

The Primary School Leaving Examinations results of Botswana show learners' poor performance in science and mathematics. Similar results are seen in Junior and Senior secondary schools and even at tertiary level the learners either avoid taking mathematics and/or science subjects or they do not smoothly sail through when they take them. Therefore, a strategy that makes teachers active participants with children who are active and inventive rather than transmitting knowledge to passive children is necessary to make the learning better (Garbett 2003 cited in Bose and Seetso, 2016).

According to (Botswana Examination Council, 2017) the percentages of mathematics candidates who were awarded grade C or better were: 28.7% in 2013, 24.5% in 2014, 24.4% in 2015, 24.84% in 2016 while 26.20% in 2017. The percentage difference between 2016 and 2017 shows an increase of 1.36%. A similar trend indicates a fluctuation as evident in 2018 and 2019 as follows: 28.60% in 2018 while 25.57% in 2019, with a decline of 3.03%. For a couple of years, students' low performance in mathematics has been a worrisome issue in Botswana (See Table 1).

Mathematics is a key aspect of our educational system because of its application in all areas of human endeavour. For example, mathematics is crucial in our daily living practices in one form or the other, be it in social or economic perspectives (Tali, et al., 2012).

Kolawole and Oluwatayo (2004) assert that mathematics is rich in concepts that directly translate to proper life skills therefore the importance of mathematics in everyday living cannot be over emphasised.

The Trend in Mathematics and Science Study (TIMSS) has revealed that students lack competition in science and mathematics as compared to other students globally (Nkate, 2008, as cited in Mareka. 2015).

A technology-based teaching and learning can include the use of educational videos, simulation, storage of data, the use of databases, mind-mapping, guided discovery, brainstorming, music, Worldwide Web (www), which will make the learning process more fulfilling and meaningful (Finger & Trinidad, 2002 cited in Ghavifekr and Rosdy, 2015).

In Botswana, the commonly used teaching method especially in Junior Secondary Schools mathematics teaching is the teacher-centred method (Garegae-Garekwe, Chakalisa and Taole 1995; Garegae, 2001), as cited in Garegae (2008).

Masole, Gabalebatse, Guga and Pharithi (2016) affirm that some initiatives have been established. For instance, in 2006, SMASSE (Strengthening of Mathematics and Science in Secondary Education) programme was introduced in Botswana for mathematics and science education whose aim was to strengthen and enhance the quality of performance, teaching and learning of mathematics and science in secondary schools. Therefore, mathematics and science teachers attended in-service training in SMASSE (Masole,et al., 2016). Despite this initiative, the performances in Mathematics and Science have not shown any improvement as clearly evident in data cited above from Botswana Examinations Council being the examining body (see Figure 1).

For meaningful learning to occur, students need to learn mathematics with understanding by actively constructing new knowledge from experience and prior knowledge. As stated by Garegae (2005), Botswana's Junior Certificate mathematics programme aims at equipping students with the basic knowledge, skills and attitudes that shall enhance their prosp ects of employment and increase their ability to use mathematics in solving daily lives' problems. Hence, incorporating technology in mathematics teaching and learning is vital for the realisation of this goal.

Kent (2001) state that although there is accessibility to technology the US Department of Education estimates that only 20% of all public school teachers feel comfortable with using technology in the classroom. Out of these teachers, 99% have access to computers and the Internet in their schools, but only 39% reported using computers or the Internet to create instructional materials; 34% used them for record-keeping; while less than 10% used them to access lesson plans, research, or investigate best practices. Although research had shown that the use of technology can improve students' achievement and self- efficacy but many reports show that teachers minimally use technology and most of them are reluctant to integrate technology into their classrooms (Mistretta, 2005).

1.2 Statement of the Problem

International experience from both developed and developing countries has shown that ICT has an enormous potential for knowledge dissemination, knowledge acquisition, effective learning and the development of more efficient education services. Botswana, like other African countries responded positively to the global trend of transforming the country into a knowledge driven society by formulating ICT policy in 1998, which was later revised in 2006. The policy was in response to the country's manifesto of Vision 2036**,** which stated that Botswana would be at the same pace with other countries that used technology. However, there seems to be a gap in incorporating technology in instructional practices, especially in mathematics. The reason could be that in most schools students get a mere introduction through Computer Awareness, a subject which is not examinable and this does not give them enough skills to use computers competently.

However, although there are many initiatives within Botswana dealing with ICT and education, efforts have largely been geared towards the deployment of ICTs to institutions through the provision of computers. As a result access is still below the standards and numbers demanded and the concerns are serious for the lower levels of education (Education and Training Sector Strategic Plan, 2015).

The national ICT draft policy of 2006 named Maitlamo which embraced all activities about ICT's concentrated on connecting the communities, government on-line, Thuto-Net (school connectivity) programme, e-health, ICT and economic diversification, and formulating laws and policies (Chakalisa et al., 2010). Despite this initiative, there is still concern on the teacher's position in incorporating technology at the classroom level.

The Thuto-Net is a project for the Schools Connectivity Initiative to connect all secondary schools to the internet. As of today, there are 104 secondary schools in Botswana that have access to the internet, and the program is being rolled out to other secondary schools. Every secondary school in Botswana has a computer laboratory with about 15-20 computers. The Thuto-Net was established to close literacy gaps between urban and rural school students. The department in charge of laying the infrastructure worked with the Ministry of Education in training teachers on using ICT as a classroom tool (Mutula, Grand, Saul, and Sebina, 2010). Although most developments have been established for incorporating technology in the teaching and learning process, it is still evident that teachers have been left out since there has been limited training hence lack of competency.

It is unclear if indeed teachers were taken on board on the use of technology in instructional practices, or they were just expected to find their way towards incorporating technology in teaching and learning or they were just reluctant to carry this nation towards realisation of the goal (Chakalisa et al., 2010).

According to Butler (2007), mathematics has a vast selection of ICT tools to make lessons very fascinating, including many and varied opportunities to bring the rich history of the subject seamlessly and enjoyably into the classroom. Based on the use of technology, issues discussed at classroom level, the study will investigate levels of deployment of Information and Communication Technology Integration in mathematics instruction at Junior Secondary Schools in the Mahalapye region.

The government, politicians, parents, students and teachers are worried about the students' poor and deteriorating performance in mathematics at junior and senior secondary schools. The percentage of students obtaining Grade A, B, and C is declining annually. The Botswana Report of the National Commission on Education: Education for Kagisano (1977) specifies that junior secondary school students should have thorough competence in all basic arithmetical operations; development of basic mathematical reasoning and problem solving with practical and real-world orientation. Despite the Botswana, Revised National Policy on Education (1994) recommendations, the students' performance in mathematics at JC continues to decline. Generally, students get better mathematics grades at primary schools but mostly they do not maintain or improve the grades at the JCE level but rather drop. As a result, the poor performance at JCE affects the Botswana General Certificate of Secondary Education (BGCSE) mathematics results (Mareka, 2015).

After the release of the 2013 BGCSE results, Tabulawa (2014) commented that mathematics was the most failed core subject. Tabulawa further stated that the continued poor performance in mathematics frustrates the government effort to channel resources towards developing mathematics and science-related fields including mining and engineering. Therefore, students might not make it into programmes like Bachelor of Science and other science based subjects. The three-year junior secondary school syllabus (2008) states that the mathematics programme will equip students with the basic knowledge, skills and attitudes that will enhance their prospects of employment and increase their ability to use mathematics in the solution of real-life problems. However, given the continued students' bad performance in mathematics at JC level shows these objectives cannot be achieved (Mareka, 2015).

The government mandate is to provide infrastructure for better implementation of the policy.

1.3 Motivation of the study

In realising that times are changing and ICT is at the forefront of various developments worldwide, the researcher was prompted to carry out a study that draws a relation between her field of work, mathematics teaching and ICT. It has come to the researchers' attention that despite governments' efforts in advocating for integration of ICT in mathematics teaching and learning, there is not much change that has occurred in how mathematics is presented. There are consistently low performance levels in mathematics among junior and senior secondary school students in the country. TIMSS 2003 and 2007 results have shown that there is poor mathematics achievement in Botswana.

It is obvious that there are several factors that could lead to this poor academic performance by students in mathematics not limited to teaching methods, transmittal techniques and other factors. It is her believe that students can use formulaic algorithms given to them by teachers without a proper conceptual understanding, hence the researcher takes on the interest to finding out how far technology has been incorporated in the teaching and learning process of mathematics, which media is commonly used and to what extent does it contribute towards students' academic performance.

In the researchers view it is essential for students to acquire and appreciate the use of technology in their teaching and learning as they experience and interact with technological gadgets more often in their daily lives. This implies that in completion of their studies, they need to have acquired some skills that would benefit them outside school. It is also stated in the ten-year basic education program (including Three-Year Junior Secondary School Syllabus) aims that technological skills and basic skills in handling tools and materials are significant important and should be incorporated in the teaching and learning of mathematics. The three year JC syllabus also aims to develop literacy and understanding of ICT and its importance in the world of work and in every sphere of life. Students are also expected to develop an awareness of computer applications in mathematics activities (Ministry of Education and Skills Development,

2008). This have motivated the researcher to find out if there is hope in achieving these goals in education by using technology in instructional practices and exposing students to new trends of learning.

1.4 Assumptions of the study

The performance of schools is still low despite the efforts and innovation put in place in the education system by Botswana government and the Ministry of Basic Education to improve the quality of education (Makwinja, 2017). The Ministry of Basic Education is given a big share of the proposed Ministerial recurrent budget amounting to P9.01 billion. This budget allocation shows Government's commitment to professional development for Batswana which is considered as very important as we move toward a knowledge-based economy (2020 Budget speech, Republic of Botswana)

According to (World Bank, 2019) Botswana's public spending of 22.2 per cent of government budget on education is relatively high as compared to her counterparts Colombia, Brazil, Costa Rica and South Africa who have same level of economic development like her. They are upper-middle-income as her. The country is experiencing the same sentiment for students' low performance even at international and regional educational assessments (e.g., Trends in International Mathematics and Science Study (TIMSS) and Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ)), and low service quality holds back the desired expansion of senior secondary education due to high failure rates on the Junior Certificate Examination (JCE) in Form 3 (Grade 10). For the education system to support inclusive and sustained economic growth, Botswana should pay attention on improving quality of education (World Bank, 2019).

The mathematics performance of students in Botswana's Junior Certificate examinations in a couple of years has either been low or there has been no improvement at all. The candidates who got grade C or better in mathematics were: in 2006, (8638) students passed mathematics with an overall percentage of 23%, 2007, (8597) with an overall percentage of 22.8% while in 2008, (8403) students passed mathematics with an overall percentage pass of 21.8% (Adedoyin,

2011). It shows that the mathematics performance of students at junior secondary school is still very low.

ICTs currently are used in every aspect of education. The rich learning environment acclimatised to modern times in technology acts as a catalyst in children because it provides social interaction and additional opportunities for learning (Zaranias, 2014). The ICTs have been internationally recommended in the mathematics education system based on the objectives for EFA and MDGs. The students with the use of computers and graphic calculators can have ample time to focus on concepts and reflect on the problem solving process. Mtshali(2012) conquer with Zaranias(2014) that ICTs are a vehicle to achieve universal basic education, thus facilitating the achievement of MDGs and EFA which lead to achievement of national goals of education. Students' performance in Botswana has been poor in mathematics at national and international levels, which can be improved with the use of technologies (Chakalisa et al., 2010).

The researcher's view is that this bad performance can be improved by a study on the investigation of the levels of information technologies in mathematics teaching and learning.

1.5 Purpose of the Study

The main purpose of this study is to explore whether or not ICT is used in mathematics teaching and learning process, the extent of usage and the common ICT media deployed. It also seeks to discover the challenges faced by mathematics teachers in integrating ICT in their teaching.

1.6 Significance of the study

National and international assessment of Batswana students has academically performed poorly in mathematics. It is that vivid evidence on mathematics teaching and learning that has become the country's major concern for all stakeholders. Hence, this study is expected to contribute to important knowledge in mathematics education. The findings and conclusions from this study will contribute to the understanding of how mathematics is taught and learnt in schools which is needed for possible curriculum restructuring, and teacher training and development. Besides this, the study seeks to answer the questions: What are the teachers' reasons for using or

not using ICT in instructional practices? What are the challenges and barriers if any in using ICT in the teaching and learning process of mathematics? Are ICTs very crucial in improving mathematics teaching and learning in schools.

It is a study with this focus that can provide useful information and data or a conceptual framework for educational authorities and policy makers on how to improve the quality of teaching and learning of mathematics.

1.7 Research Questions

The proposed study will seek to answer the following research questions:

1. What are the levels of deployment of ICTs in teaching and learning mathematics at the junior secondary level in the Mahalapye region?

2. How do junior secondary school mathematics teachers in the Mahalapye region deploy ICT media in their teaching?

1.8 Objectives of the Study

In an attempt to address the above research questions, the researcher shall use the following research objectives as the main drivers to the solutions of the research questions. Thus, the following specific objectives shall be key:

1. To determine the levels of deployment of ICTs in the teaching and learning of mathematics at the junior secondary phase in the Mahalapye region.

2. To determine the common media deployed by mathematics teachers in their teaching.

1.9 Theoretical Framework

The research is focused on investigating the use of ICT in the teaching and learning process at the junior secondary school level to help construct meanings. In mathematical pedagogy, integrating ICT tools is based on certain philosophical perspectives on mathematics and the role of ICTs. Therefore, this study will adopt a constructivism framework in which all knowledge is invented or "constructed" in people's minds. People create knowledge, ideas and language because they are useful to them (Nkhwalume, and Liu, 2013). Constructivism views knowledge as being constructed by students from their previous knowledge. The student interacts with his/her environment and gains an understanding of its features and characteristics. The student constructs his/her own conceptualizations and finds his/her own solutions to problems, mastering autonomy and independence. Thanasoulas (2002) argues that in constructivist thinking, learning is inescapably affected by the context and beliefs and attitudes of the student. The students are here given ample time in becoming effective problem solvers, identifying and evaluating problems, and deciphering ways in which to transfer their learning to these problems (Gebrekal, 2007).

A constructivist learning is based on students' active participation in problem-solving and critical thinking regarding a learning activity that they find relevant and engaging. They are "constructing" their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to a new situation and integrating the new knowledge gained with pre-existing intellectual constructs. In this view, knowledge is gained by an active process of construction instead of passive assimilation of information or rote memorisation. This view of learning contrasts with one in which the passive transmission of information from one individual (teacher) to another (student), a view in which reception but not construction is the key (Gebrekal, 2007).

Mathematical knowledge cannot be transferred from one person (teacher) to another (student) but it should be constructed by every student in constructivist learning theory. The students are active meaning- makers who constantly construct their own meanings of ideas communicated to them based on their own existing knowledge. This suggests that a student finds a new mathematical idea meaningful if he/she can form a new concept (Bezuidenhout, 1998,

p.390), as cited in Gebrekal (2007). Reys, Suydam, Lindquist and Smith(1998, p.19) mention three basic tenets on which constructivism rests, namely: "Knowledge is not passively received, but it is actively created or invented (constructed) by students; Students create (construct) new mathematical knowledge by reflecting on their physical and mental activities; Learning reflects a social process in which children engage in dialogue and discussion with themselves and others (including teachers) as they develop intellectually" p. 19 (Gebrekal, 2007). Teachers go from being a direct lecturer, or giver of information, to more of a facilitator of student learning through discussion (Hoffman et al., 2012, cited in McAninch, 2015).

Bullard (2003), cited in Kennah, 2016) a proponent of the constructivist view of learning, views it as a process in which individuals construct meaning based on prior knowledge and experiences. Constructivists view the learner as an active participant involved in structuring their learning experience as opposed to the behaviourist view. Bullard (2003), cited in Kennah (2016) believes that applying constructivist principles in the teaching and learning process will generate a new way of teaching with computers, making up a shift from a teacher-centred to learner-centred pedagogy.

This study is based on Social-constructivism. According to Ernest (1991), social constructivism views mathematics as a social construction. With the use of language and social interchange (that is the negotiation between the teacher and the students and among the students), individual knowledge (understanding can be expressed, developed and contested). Only in mathematics is this type of constructivism developed. According to this theory, mathematics is a creative human activity and mathematical learning occurs as students develop effective ways to solve problems. On a similar note, Jones (1997) remarks that, "knowledge is the dynamic product of the work of individuals operating in the communities, not a solid body of immutable facts and procedures independent of mathematicians" (p.145). Learning in this view is considered more than a matter of meaning-making and of constructing one's own knowledge instead of memorising mathematical results and absorbing facts from the teacher's mind or the textbook; Teaching is the facilitation of knowledge construction but not delivery of information (Gebrekal, 2007).

Social constructivism emphasizes the role of the teacher, parents, peers and other community members in assisting students to master concepts that they could not understand on their own. For social constructivists, learning must be active, contextual and social. It is best done with the teacher as a facilitator or guide in a group setting (Tinio, 2003).

Proponents of the socio-constructivist theory claim that when individuals (students and teacher) work together in the classroom setting, they share opinions and experiences which lead to knowledge construction and therefore, knowledge or understanding is socially constructed (Ernest, 1991; Stein, Silver and Smith, 1998), as cited in (Gebrekal, 2007). According to Vygotsky in Nicaise and Barnes (1996, p.207) cognitive development relies on the child's social interaction with others in which language plays a pivotal role in cognition articulated in the importance of social discourse. Vygotsky believes students' thinking and concept formation (schema) is guided by social interaction. Conceptual growth occurs when students and teachers share different viewpoints and experiences and understanding changes in response to new perspectives and experiences (Nicaise and Barnes, 1996, p.207), as cited in (Gebrekal, 2007). The researcher believes this framework will fully inform the study as the teachers are facilitators while students construct meanings through using ICT to learn mathematics.

1.10 Definition of key terms

ICT refers to all technology that can transmit, store, create, share or exchange information (UNESCO, n. d.). It includes scientific calculators, email, internet and telecommunications, computer technologies and accessories (Garegae and Moalosi, 2011).

Computer awareness is how computers may impact education. Computer awareness programme acquaints the students/teachers with the computer technology and the basic principles on which a computer includes some elementary BASIC programming (Yusuf, 1998a, as cited in Onasanya, Shehu, Ogunlade and Adefuye, 2011).

Internet - A "network of networks" connecting millions of computers worldwide for communications (Botswana's Draft National Information and Communications Technology Policy V 01, 2005).

E-learning: The delivery of a learning, training or education programme by electronic means using technologies like a computer or an electronic device like a mobile phone to provide training, educational or learning material (Mutula, 2010).

Maitlamo: Botswana brand name for the National ICT policy (‘Maitlamo’ means commitment) (Mutula, 2010).

Non-participant observation: This is a term that is used to describe a situation in which the observer observes but does not participate in what is going on in the social setting (Bryman, 2012, 273).

Vision 2016: Botswana long term development strategy (Mutula, 2010).

Chapter 2

Literature Review

2.0 Introduction

This chapter discusses the literature and research that has informed this study. The chapter begins with an overview of current research and literature then presents the links to the theory that underpins the integration of ICT in mathematics teaching and this study. This is then followed by the argument for deploying ICT in mathematics teaching and learning. The researcher explores research on challenges brought by the deployment of ICT in mathematics teaching and learning. The review draws upon literature from Western countries, Southern African Development Community (SADC) countries and the entire African continent.

The researcher also examined literature related to studies of this nature with a purpose of ensuring that the proposed research methodologies are considered appropriate to reveal meaningful findings for this study and the phenomenon being investigated. This was done because research designs and methodologies are known to vary and to be applicable to different research purposes.

2.1 Importance of mathematics

To be very knowledgeable in mathematics is considered a gateway to tomorrow's jobs in various fields (Tella, 2008; Pandor, 2006; De Klerk Wolters) as cited in (Tachie and Chireshe, 2013). Our routine activities rely on mathematics dealing with real-life situations (Ojose, 2011 as cited in Tachie and Chireshe, 2013). It is regarded an asset for applicants to be well conversant in mathematics in order to get better employment globally. It is essential to be skilful in mathematics to prepare numerate citizens for employment which is needed for the ongoing production of highly skilled people needed by industry, science and technology (Mikulski, 2001; Steen, 2001; House, 2006) as cited in Tachie and Chireshe, 2013). Steen (2001) as cited in Tachie and Chireshe (2013) argues that mathematics empowers people to take control of their lives and provide science with a firm foundation for effective theories and also guarantees society a vibrant economy.

Mathematics is found in almost the entire world's socio-cultural, economic and political environments. For example, in adult life, mathematics is required for thinking and quantitative skills (Lekoko and Garegae, 2006; Garegae, 2004; Lave, 1988). Social activities such as cooking, shopping, laundry, taking medication, reading and interpreting graphical and quantitative information from newspapers, radio and television require someone very knowledgeable in basic mathematics (Garegae and Chakalisa, 2005). The value of Mathematics can be observed in daily life activities with or without our awareness, for instance women in Botswana beautify floors and walls with cow dung by making geometrical patterns. In addition to that, Mathematics is needed for decision making in business hence businesses require the best combination of factors of production to minimise costs while maximising profit. Therefore, it is necessary to be very knowledgeable in linear programming**.**

Mathematics is regarded as essential for Science and Technology in the school curriculum (Mogotsi, 2004, as cited inGaregae and Chakalisa, 2005). Jaiyeoba and Atanda (2011), affirm that mathematics is needed for economic development of a nation to produce versatile and resourceful graduates. Mathematics is an important science subject for understanding most other fields in education (Setidisho, 1996, as cited in Jaiyeoba and Atanda, 2011). Odusoro (2002), as cited in Jaiyeoba and Atanda(2011) asserts that the science knowledge remains shallow in the absence of mathematics.

It is vital for everyone to think and reason. (Marquis de Condorcet as quoted by Fitzgerald and James, 2007: ix) states: "Mathematics … is the best training for our abilities, as it develops both the power and the precision of our thinking." The National Research Council, USA (NRC, 1989:1), reminds us that: "Communication has made a world economy whereby working smarter is crucial than working harder… We are in need of workers who can absorb new ideas, to adapt to transformation, to cope with ambiguity, to perceive patterns and to solve unconventional problems". These two statements show the importance and relevance of both mathematics and technology, primarily ICT in our daily lives (Shadiq, Iryanti and Subanar, 2010). Mathematics is needed for the learning of science because of generating essential knowledge required for the advancement of human needs and wants (Garegae, 2012). Outstanding achievement in mathematics determines good economic growth (Ogunniyi, 1995), as cited in (Garegae, 2012).

The developed and developing countries aim at harnessing the potential in ICT to improve mathematics performance. African countries including Botswana have also embarked on this journey (Garegae, 2012).

Mathematics is of importance to society because of its broad application in science, technology, economy, agriculture, business and other social activities. Therefore, mathematics programmes prepare students for active and constructive participation in society. Mathematics has contributed tremendously to the comprehension and acquisition of modern techniques and technologies required in the ever-changing modern world. The students' development of intellectual growth and be able to think logically and critically can be achieved through learning mathematics. They can develop an appreciation for patterns, structures and relationship models and describe the world around them. They can also develop problem-solving skills and inquiry strategies (Tachie and Chireshe, 2013).

Presently, the world's technological advances' leading to job opportunities is due to someone who is very knowledgeable in mathematics (NCTM nd, Steen, 2001; Kahn, 2001) as cited in (Tachie and Chireshe, 2013). Mathematics is a necessity for science, computer technology and engineering courses therefore, schools must have effective teaching and learning of mathematics from grade one to university level (Department of Education, 2000). Despite the importance of mathematics, students continue failing it (Feza-Piyose, 2012), as cited in (Tachie and Chireshe, 2013).

Mathematics is regarded as the basis for many successful careers and lives; therefore, the concern about a higher level of mathematical skills and knowledge cannot be ignored (Golafshini, 2002). Hence, it is important to make our students knowledgeable and skilful in mathematically inclined careers (Golafshini, 2002).

Mathematics is considered the cornerstone of scientific and technological knowledge needed for socio-economic development of every nation. Therefore, other African countries including Botswana have made mathematics a compulsory subject. In Kenyan primary and secondary schools, mathematics is used as a basic entry requirement for any prestigious courses like medicine, architecture and engineering among other degree programmes.

2.1.1 Teaching methods applicable for mathematics teaching

There are several teaching methods and strategies that can be used in the effective and efficient teaching and learning of mathematics. Various strategies and teaching methods need to be used and individual plans need to be adapted to meet the student's requirements (Gezahegn, 2007). The existing teaching methods in schools are much traditional and less activity based and mainly dependent only on the teacher's performance (Jahan, 2010). The students learn best by touching, seeing, smelling and testing instead of just listening (Hossain, 2000). Gezahegn (2007) mentions that in order to understand mathematics, there is need to give a lot of exercises and practice because of its nature. As a researcher, I support the idea of letting students learn by touching and seeing with the use of ICTs instead of just listening to the teacher as mentioned by (Hossain, 2000), as cited by (Pia, 2015).

It is apparent that the best teaching methods have to be used in order to enhance effective teaching and learning hence the old Chinese adage which says 'what I hear I forget what I see I remember and what I do I know. Educators have come to realize that the most effective teaching and learning takes place when an individual has direct experience with the subject under study, in other words, learners learn best by doing (Ode, 2019).

Worldwide, the rapid development of ICT in recent years has dramatically increased its availability in mathematics classrooms (Geiger et al., 2012; Lagrange and Kynigos, 2014). The wide availability of ICT, including computers, graphic calculators, versatile interactive software, and web-based applications, has mostly changed students' mathematical practices, like ways of constructing and applying mathematics knowledge (Goos and Bennison, 2008; Jimoyiannis and Komis, 2007). There is a view that ICT is an effective tool allowing mathematics teachers to change from teacher-centred teaching strategies to student-centred constructivist teaching strategies (Goos and Bennison, 2008; Pierce and Ball, 2009), as cited in Yang, and Leung (2015).

Schools are expected to use ICT like computers, visual aids or other media to improve the effectiveness of mathematics instruction. The ICT is vital in education, especially in the teaching of mathematics and science in this era of globalisation (Shadiq, 2010). Wenglinsky (1998) used data from the 1996 National Assessment of Educational Progress (NAEP) in Mathematics to study the effects of teachers' use of instructional technology on student achievement in mathematics and the findings have shown that when computers are correctly used can improve students' mathematics achievement and enhance the overall learning environment of the school (Mistretta, 2005). Nabbout and Basha (2000) affirm that ICT usage in teaching school subjects, especially mathematics, can improve quality performance and classroom experience. It is believed that ICT can rejuvenate students' pleasure and make meaningful learning because mathematics globally is considered a difficult, abstract and mostly failed subject (Mistretta, 2005).

Ittigson and Zewe (2003) argue that technology is important in the teaching of mathematics because it improves the way mathematics should be taught and also boosts student's understanding of basic concepts. Becta (2008) summarised the benefits of ICT as promoting greater collaboration among students and encouraging communication and the sharing of knowledge. With the use of ICT, students get fast and correct feedback, leading to positive motivation. It also allows the students to focus on strategies and interpretations, unlike spending more time on tedious computational calculations. Constructivist pedagogy is being supported by ICT while working with it through exploring and understanding mathematical concepts. The constructivist approach promotes higher order thinking and better problem-solving strategies, which are the recommendations of the NCTM; students would use technology to focus on problem-solving processes rather than just calculations linked to the problems (Ittigson and Zewe, 2003, as cited in Keoreng, Horani and Daniel, 2005).

2.2 ICT deployment in mathematics education

From the above section, it is clear that there is a need to deploy ICT in mathematics education for various reasons. Deploying ICT in mathematics education would have some significant impact as it promotes students' engagement, especially in the 21st century as they gain and apply skills relevant for the work field and common life practices. Hechter, Phyfer and Vermette (2012) emphasise that by stating that, integration of ICT in mathematics teaching and learning process promotes student engagement, teaches 21st century skills, best teaching practice allowing them to stay hands-on interactive learning, to vary instructional methods, to perform labs and demonstrations and for research and communication as cited in Amuko (2016). There are several factors that influence a deployment of ICT in mathematics education. We can categorise these factors according to how they relate to the school or the education system, the teacher, the students and the technological tools.

There are different factors that are related to the school, and these may include:

- The available technical support for the teacher. Thus, how teachers are supported in deploying ICT in their teaching has a significant impact. Teachers need to be supported by the curriculum they are delivering, the school management and all the stakeholders that have a major role in ensuring that the educational goals and standards are met.

- The quantity, quality and type of guidance. Since teachers are mandated to implement the curriculum, they need to be guided on how to effectively and efficiently implement the set standards.

- The other imperative factor is the organisation of equipment in the school, where this organisation would better ensure maximum access for all users and school resistance for change, such as a necessary organisational change enabling successful ICT use in the school.

Factors related to the teacher could be:

The teacher's self-confidence regarding the use of technology, personal access level of the teacher for the ICT tools, availability of a teacher's time to get to know closely and deeply the hardware and software needed to use ICT in the classroom and the availability of teachers time to prepare learning materials suitable for the use of ICT in teaching. Another issue related to the teacher regarding ICT use in the classroom is associated with the resistance to change resulting from the non-willingness of teachers to change their teaching methods, and as a result their integration of ICT in the classroom is prevented or slowed. A different issue related to the teacher regarding ICT use in the classroom is the awareness or unawareness of the benefits of ICT use in teaching and learning. Further, teacher's attitude towards the ICT affects his/her use of ICT in the classroom and teacher's gender may affect the ICT use where male teachers use ICT in their teaching more than female ones.

Factors regarding ICT use in the classroom and related to tools could be:

Tools'operational technical problems, where they could decrease the use of the tools as personal tools, and, as a result, their general use in the classrooms. These problems would lower the self-confidence of teachers and as a result decrease their use of ICT.

Factors regarding ICT use in the classroom and related to the system could be:

Teachers' training programs at colleges and universities, where ICT related training programs develop teachers' competences in computer use and positively affect their attitudes towards computers. These potentialities of teachers' training programs will be realised on condition that teachers are trained practically in personal and classroom uses of ICT tools; in particular, teachers ought to be trained to prepare varied learning materials appropriate for integrating ICT in teaching and learning.

2.3 Benefits of ICT in the teaching and learning of mathematics

ICT can be an effective tool in supporting the teaching and learning process when used appropriately for specific purposes in specific contexts. Therefore, it is worth mentioning that there are several benefits that can be outsourced from deploying ICT in the teaching and learning process.

2.3.1 Assist students in accessing digital information efficiently and effectively

According to Brush, Glazewski and Hew (2008) ICT is used as a tool for students to discover learning topics, solve problems and provide solutions to the problems in the learning process. ICT makes knowledge acquisition more accessible, and concepts in learning areas are understood while engaging students in the application of ICT (Fu, 2013).

2.3.2 Support student-centred and self-directed learning

Students are now more often involved in a meaningful use of computers (Castro Sánchez and Alemán, 2011). They construct new knowledge through accessing, selecting, organising and interpreting information. Based on learning through ICT, students are more capable of using information and data from various sources and critically assessing the quality of the learning materials (Fu, 2013).

2.3.3 Produce a creative learning environment

ICT develops students' new understanding in their areas of learning (Chai, Koh and Tsai 2010). It provides more creative solutions to different learning inquiries. For example, in a reading class, e-books are commonly used in reading aloud activities. Students can access all types of texts from beginning to advanced levels with ease through computers, laptops, personal digital assistants (PDAs) or i-Pads. More specifically, these e-books may come with some reading applications, which offer a reading-aloud interface, relevant vocabulary-building activities, games related to reading skills and vocabulary acquisition and more. Therefore, ICT involves purpose designed applications that provide innovative ways to meet a variety of learning needs (Fu, 2013).

2.3.4 Promote collaborative learning environment

To prepare for the global economy, students must be able to collaborate and apply knowledge and skills to real-world situations. Learning cannot simply consist of memorizing facts or information and should not be disconnected from the real world. Many proven instructional strategies involve opportunities for students to collaborate with one another while applying knowledge to relevant situations, including project-based learning (Wolf, 2012).

According to Koc (2005), using ICT allows students to communicate, share and work collaboratively anywhere, anytime. For example, the students might gather around the world at the same time for a topic discussion in a tele-conferencing classroom. Here they may have time to analyse problems, explore ideas and also develop concepts. They may further evaluate ICT learning solutions. The students not only gain knowledge together but also share different learning experiences from each other to express themselves and reflect on their learning (Fu, 2013). Collaborative learning: ICT-supported learning encourages interaction and cooperation among students, teachers and experts no matter where they are. Besides modelling real world interactions, ICT-supported learning provides an opportunity to work with students from diverse cultures, helping to enhance learners' teaching and communication skills and their awareness globally. It models learning done during the learner's lifetime by expanding the learning pace to not include only peers but also mentors and experts from various fields (Mikre, 2011). Technology is important in teaching and learning mathematics because of influencing the mathematics that is taught and enhancing students' learning. ICT can transform the nature of education; improving the teacher's design work, enhancing the roles of students and teachers in the learning process and help create a collaborative learning environment (Khan, Hossain, Hasan and Clement, 2012).

Technology can be used as a tool for establishing meaningful projects to engage students in critical thinking and problem solving. It can be used to restructure and redesign the classroom to produce an environment that promotes the development of higher-order thinking skills (Kurt, 2010). Technology also increases student collaboration. Collaboration is a highly effective tool for learning. Students cooperatively work together to either create projects or they can learn from each other by reading the work of their peers (Keser, Huseyin, &Ozdamli, 2011) cited in Costley (2014).

2.3.5 Improve teaching and learning quality

The use of ICT in teaching and learning would enable teachers to design their lesson plans in an effective, creative and fascinating way that would cause students' active learning. Previous research has shown that the usage of ICT in teaching will enhance the learning process and maximise their abilities in active learning (Finger & Trinidad, 2002; Jorge et al., 2003; Young, 2003; Jamieson-Procter et al., 2013). For example, Microsoft Power Point can be used to present the topic in a very innovative and creative way that will lead to discussion and exchanging ideas and thoughts. The complementary approach will also be used here whereby the ICT is used to aid and support the student's learning. This approach allows the students to be more organised and efficient because they can obtain the notes from the computer, submit their work by email from home and seek for information from various sources online for the task given by the teacher to research on (Hermans et al., 2008) cited in (Ghavifekr and Rosdy, 2015).

ICT can encourage and support a meaningful two-way flow of information between teachers and students, moving away from the traditional strategy in which knowledge is transferred from the teacher to students with no critical analysis by the student (Wims and Lawler, 2007).

The use of ICT is making major differences in the students' learning and teaching approaches (Volman, 2005). Several studies have shown that students who use ICT facilities mostly show higher gains than those who do not. For instance, Kulik's (1994) finding in the United States across 75 studies had shown that the students who used computer tutorials in mathematics, natural science and social science score significantly higher on tests in these subjects. Also, students who used simulation software in science scored higher.

Voogt (2003) distinguishes between traditional learning setting and constructivist approaches. The former considers learning as the transmission of knowledge to students, which is the sole responsibility of the teacher. In contrast, the constructivist approach considers learning as authentic and learner- centred. For example, the computer is of great help in the constructivist approach whereby one can design simulated and individualised learning environment to the students (Voogt, 2003) from (Voogt and odenthal, 1997; Wijnen et al., 1999), as cited in (Mikre, 2011).

Active learning: ICT- enhanced learning mobilises tools for examination, calculation and analysis of information to give a platform for student enquiry, analysis and construction of new information. Therefore, students learn as they do and are able to work on real-life problems in-depth. ICT also makes learning less abstract and more relevant to life situations in contrast to memorisation-based or rote learning, which is the feature of traditional pedagogy (Mikre, 2011).

Creative learning: ICT-supported learning promotes the manipulation of existing information and the creation of real-world products rather than a duplication of received information. According to Lowther et al. (2008), as cited in Fu (2013) there are three main characteristics vital for development of good quality teaching and learning with ICT: autonomy, capability and creativity. Autonomy is when students take control of their learning with the use of ICT and they become more capable of working by themselves and with others. Teachers can also let students to complete certain tasks with peers or in groups. The students have more time to build new knowledge on their background knowledge and become more confident in taking risks and learning from their mistakes through collaborative learning with ICT. Serhan (2009) cited in Fu(2013) stated that ICT nurtures autonomy by allowing educators to create their own

materials, thus providing more control over course content than is possible in a traditional classroom setting, regarding capability to apply and transfer knowledge while using new technology with efficiency and effectiveness. Students' creativity can be improved by using ICT. The ICT usage can improve both quality of teaching and learning (Fu, 2013). It is widely accepted that deploying of modern information and communication technologies into the teaching-learning process has great potential as a tool in supporting the learning process. ICT can increase the students' self-confidence and competencies (Sithole and Lumadi, 2012).

It is commonly believed that ICT is an effective tool for allowing mathematics teachers to change from using teacher-centred teaching strategies to student-centred constructivist teaching strategies (Goos and Bennison, 2008; Pierce and Ball, 2009), as cited in Yang and Leung (2015). The ICT usage can enrich students' mathematics learning experience and improve their interest in learning mathematics and change their attitudes towards mathematics (Goos and Bennison, 2008; Jimoyiannisa and Komis, 2007; Perce and Ball, 2009), as cited in Yang and Leung (2015). The effective integration of ICT can make mathematics (e.g., abstract concepts) more accessible to students and further facilitate students' understanding of mathematics concepts, develop students' problem-solving skills, improve students' higher levels of mathematical thinking and also improve students' mathematics achievement (Goos and Bennison, 2008; Li and Ma, 2010), as cited in Yang and Leung (2015).

With the use of ICT, teaching and learning cease to rely on printed materials. Many resources can be found on the Internet and knowledge can be attained through video clips, audio sounds and visual presentation. Present research has shown that ICT helps to change a teaching environment into a learner-centred one (Castro Sanchez and Aleman, 2011) as cited in Fu (2013). Prestride (2012) states that ICT packages are crucial for teachers because they assist in creating of lesson plans, analyzing and setting students' tests, acquiring new knowledge and vividly presenting lessons among others.

2.3.6 Support teaching by facilitating access to course content

According to Watts-Taffe et al. (2003) teachers can act as catalysts for the integration/deploying of technology through ICT. If the encouragement, equipment and necessary technological support are availed by institutes for the teachers, it will be easier for teachers to develop an ICT class. The main responsibilities of these teachers will be to change their course format, creating and explaining the new assignments and arranging for the computer lab through their technology learning specialists or assistants.

According to Reid (2002) ICT offers students ample time to explore beyond the mechanism of course content letting them to better comprehend concepts. Using ICT also changes the teaching learning relationship. Based on the findings of Reid's study, teachers reported that the relationship between teacher and learner is sometimes reversed regarding information technology. This relationship boosts students' confidence when they can help teachers with technical issues in the classroom. Therefore, ICT changes the traditional teacher-centred approach and requires teachers to be more creative in customising and adapting their own material.

The new culture and digital learning provides opportunities to shift the teacher's role from a disseminator of knowledge to a facilitator of learning. In the past, teachers and/or textbooks provided the majority of information and content to students. With the internet, digital content, and the ever-growing body of technological resources, students now have access to material on demand. This contributes to a shift in how teachers can spend the time they have with their students and the interaction and assignments when they are not together. Teachers can guide students in their learning and help them navigate information and resources and understand content; they can also help students think about and create their own knowledge base. A teacher can focus efforts on asking questions, pushing students to develop their own products or knowledge, and providing opportunities for students to collaborate and utilize higher-level thinking skills (Wolf, 2012).

2.3.7 ICT facilitates the acquisition of basic skills

Effective citizens and workers are needed to have functional and critical skills like information literacy, media literacy and ICT literacy in the 21st century (Partnership for 21st century learning, 2015). Therefore, teachers are expected to instil those functional and critical thinking skills to enable future citizens and workers to be competitive. The teachers need to be competent in the use of ICT. They need to be prepared to provide their students with technology supported learning environment to support student learning (UNESCO, 2008) as cited by Aslan, and Zhu, 2018).

Based on the constructive learning approach, ICT helps students to focus on higher-level concepts instead of less meaningful tasks (Levin and Wadmany, 2006), as cited in Fu (2013). McMahon's study (2009) as cited in Fu (2013) showed that there are statistically significant relations between studying with ICT and the acquisition of critical thinking skills. Students' higher critical thinking skills can be acquired by being exposed to the ICT atmosphere for a longer time. Where this is done, students can apply technology to the attainment of higher levels of cognition within specific learning contexts (Fu, 2013). ICTs can facilitate the transmission of basic skills and concepts that are the foundation of higher order thinking skills and creativity through drill and practice (Tinio, 2003).

Review studies indicate that ICT in teaching and learning of mathematics helps students in developing problem-solving skills, practice number skills and explore patterns and relationships, for example, by visualising different and complex structures, challenging students' thinking and understanding and illustrating graphically how misconceptions can be (Van Braak, 2001; Sagra and Gonzalez- Sannamed, 2010), cited in Witte and Rogg (2014). Agyei and Voogt (2010), cited in (Kennah, 2016) argue that using ICT constructively will increase students' critical thinking, encourages small group activities and also encourages cooperation between students and teachers.

Several studies have shown that ICT is a vital part of the global world. It's value in schools is to help in creation of knowledge, sharing of knowledge, problem-solving, communication, group and cooperative learning, the development of economic and social change. Tedla (2012) has stated that there are new technologies that can promote and transform teaching-learning processes. He mentions that ICTs can provide effective teaching-learning atmospheres by providing opportunities for effective communication between teachers and students. The new technologies also assist students in the development of knowledge and skills, cooperation, communication and problem solving. Tay et al. (2012) also found that the use of drill and practice in mathematics allowed students to master basic computational and arithmetic skills and the immediate feedback worked as a motivational source for more encouragement in the learning activities. Siemens computer and cell phone games help in developing required skills like problem-solving, which are expected to be mastered by students.

The skills of locating, evaluating and using information from different sources constitute the Information Skills people require, which lets them get involved in effective decision making, problem-solving and research. Therefore, the importance of ICT cannot be over emphasized because it offers the education process one of the most potentially powerful learning tools available. Computers support learning across the whole curriculum while communication networks offer fast and searchable access to huge amounts of information to the student. Computers support a wide range of broader educational objectives like independent learning, collaboration with others and communication skills (Hunt, 2004). It is vital for all students in schools to have enough access to ICT and to develop the skills, taking advantage of the learning capabilities that ICT provide (Motshegwe, 2005). Teachers need more knowledge of and confidence with ICT and a better understanding of its potential to assist students learn. Constant teacher professional development is important so they can integrate these technologies and infuse ICT issues in the teaching to improve students' attainment (Cox et al., 2003).

The use of ICT in the teaching of mathematics can make one acquire the necessary skills needed for the world of work. Currently, very few jobs do not require the use of technological skills, but collaboration and teamwork can be learned through teaching with ICT. (Aladejana, 2007). Skills like book-keeping, clerical and administrative work, stocktaking, now constitute a set of computerised practices that form the core IT skills package: spread sheets, word processors, and databases (Reffell and Whitwort, 2002).

Thinking skills can be developed with the use of ICT, especially computers and telecommunication networks. Computer applications have been adapted or developed to facilitate critical thinking and higher-order learning. These tools let students represent and express what they know and lead to them as designers of artefacts. They construct knowledge bases, expert systems and multimedia presentations representing appropriate and meaningful knowledge, thus engaging them in higher-order, mindful thinking and learning (Salomon and Globerson, 1987). There is an establishment of intellectual partnership when students use technologies in which the computer will strengthen their thinking. Cognitive tools aim at making students think harder about the content being studied which would be impossible without these tools.

2.3.8 ICT enhances teaching and learning processes

Research studies have found the necessity of deploying ICT in education as capable of enhancing a student's intellectual qualities through higher order thinking, problem-solving, improved communication skills and deep understanding of the learning tool and the concepts to be taught (Sutton, 2006, as cited in Hedges et al., 2000). ICT can promote a supportive, interactive teaching and learning environment, create broader learning communities and provide learning tools for students even those with special needs (Trinidad et al. 2001; Hawkins 2002, as cited in Hedges et al., 2000). Computer-generated graphics have been used to illustrate relationships of all kinds, especially dynamic processes that cannot be illustrated by individual pictures (Franke, 1985, as cited in Hedges et al., 2000). They also improve school attendance levels and enable the creation of a new and more effective curriculum (Hedges et al, 2000).

Most experts concur with each other that ICT when correctly used can improve teaching and learning and shape workforce opportunities. The schools in developing countries had been furnished with computer facilities requiring qualified people to produce technologically proficient and efficient students. According to Burnett (1994), Fitzgerald and Warner (1996) as cited in Aduwa- Ogiegbaen and Iyamu (2005) computers can help the instructional process and facilitate students' learning and many studies have found a good impact associated with technology aided instruction.

The use of technology can replace the paper-and-pencil approach that had been used for many years in the teaching and learning of mathematics. Computers allow for mathematical problem-solving and graphing opportunities in the teaching and learning of mathematics due to the convenient, exact and dynamic drawing, graphing and computational tools (NCTM, 2003). Computers give students an opportunity to explore applications and concepts which would be tiresome and time consuming with the paper-and-pencil methods. Now, secondary school students can learn mathematics in a less tedious way with graphing technologies, especially computers. According to Dunham and Dick (1994, 444), "graphing technologies can be used in functions and graphs." The Curriculum and Evaluation Standards for School Mathematics NCTM (1989) recommend that frequent use of computers can change the mathematics curriculum (Chakalisa, et al., 2010).

Wenglinsky (2000) also used the 1996 NAEP data to show the positive effects of using instructional technology to develop higher order thinking skills in the mathematics classroom. Wright (1999) argues that interactive learning with the use of technology leads to higher student achievement, self-concept, attitude and teacher-student interaction. According to Kerrigan (2002) the use of mathematics software and websites would improve students' higher-order thinking skills. Developing and maintaining their computational skills, introducing them to collection and data analysis, facilitating their algebraic and geometric thinking and showing them the role of mathematics in an interdisciplinary setting.

The results from published studies on the relationship between computer use and academic achievement have shown that technology can increase students' outcomes (Becker, 1994; Christmann and Badgett, 1999; Hativa, 1994; Kozma, 1991; Kulik and Kulik, 1987; Liao, 1992; Niemiec and Walberg, 1987; Niemiec and Walberg, 1992; Ryan, 1991; Van Dusen and Worthen, 1994). Results have shown in mathematics achievement studies that, significant positive effects occur when using computers (Clariana and Schultz, 1988; Mayes, 1992; Mevarich, 1994; Moore, 1988; Rhoads, 1986; Van Dusen and Worthen, 1994, as cited in Hedges et al., 2000).

Global network technology can give students the platform to develop their social, communication and collaboration skills by participating in online discussions. The students' outlook will be broadened with their exposure to greater diversity in perspectives through participation in global discourse (Chan, 2002).

The development of ICT in institutions of Higher Education has resulted in innovative forms of delivering instruction. The constructive perspective of learning states that "knowledge is built by the learner, not supplied by the teacher" (Papert, 1990, p.3). New teaching and learning strategies may have to be introduced to prepare students to become independent learners, which may be supported with the use of ICT. The teachers can give students time to learn to think critically and discuss with their peers through the use of ICT (Olsen, 2000). Giffioen, Seales, and Lumpp (1999) argue that with the correct use of technologies, students' learning can be more interesting and enriching and it is of great importance for educators to make serious considerations of matching the correct use of technology with the content to inculcate the student's capability in learning. Frand (2000) argues that with introducing technology the educator's role of teaching the students should change. The phrase "sage on stage" may change to "guide on the side" as educators can move backward from the normal role of being information giver to one that guides the learning process of the student. Soloman (1999) argues that there are many forms of using technology. The teacher can provide students with real and authentic experiences (Koon and Khine, 2001).

Most countries were moving at a slow pace to include technological innovations in their formal education. There is a shift of instruction from teacher - centred to student - centred practices that promote collaborative and cooperative learning. These proposed reform visions can be accomplished within the ICT integration curriculum, which promotes deeper mathematical reasoning. The technology has been used in mathematics in analysis (Moormann and Grob, 2006), Algebra (Abramovich, 1999; Ainley, Bills and Wilson, 2005; Dreyfus and Hillel, 1998), statistics (Abrahamson and Wilensky, 2007), Geometry (Cobo, Fortuny, Puertas and Richard, 2007; Healy and Hoyles, 2001; Laborde, 2001). Internet is increasingly being used to promote collaborative and interactive learning (Cazes, Gueudet, Hersant and Vandebrouck, 2006; Cress and Kimmerle, 2008; Resta and Rafferriere, 2007) also (Lavy and Leron, 2004). ICT improves the efficiency of mathematical thought, permits students to make conjectures and immediately test them in no-threatening environment (Laborde, 2001, as cited in Ogwel, 2015).

ICTs can innovate, accelerate, enrich and deepen skills, to motivate and engage students, to assist relate school experience to work practices, create economic viability for future's workers and strengthening teaching to assist schools change (Davis and Tearle, 1999; Lemke and Coughlin, 1998 cited by Yusuf, 2005). ICT brings a new learning environment for students, thus wanting a different skill set to be successful. Critical thinking, research, and evaluation skills are essential as students gain more information from different sources to sort through New Media Consortium (2007). Teachers should arouse students to engage in active knowledge construction, which calls for open - ended learning environments instead of learning environments only concentrating on the transmission of facts (Collins, 1996; Hannafin, Hall, Land, and Hill, 1994; Jonassen, Peck, and Wilson, 1999).

ICT can provide opportunities to access a wealth of information with the use of multiple information resources and seeing information from multiple perspectives, thus fostering the authenticity of learning environments. ICT may also make complicated processes simpler to comprehend through simulations, which contribute to authentic learning atmospheres. Hence, ICT may act as a facilitator of active learning and higher - order thinking (Alexander, 1999; Jonassen, 1999). Using ICT may lead to co-operative learning and reflection about the content (Susman (1998). ICT may serve as a tool to curriculum differentiation, giving opportunities for

adapting the learning content and activities to the needs and abilities of every student and by giving tailored feedback (Mooij, 1999; Smeets and Mooij, 2001). ICTs can enhance the quality of education in various forms, by increasing student motivation and engagement, by facilitating the acquisition of basic skills, ICTs are also transformational tools which when used correctly can promote the move to a student- centred atmosphere. ICTs, particularly computers and internet technologies, enable new ways of teaching and learning by allowing teachers and students to do what they have been doing in a better way.

ICT offers motivation for learning and gadgets like videos, television and multimedia computer software that combine text, sound and colourful moving images can give a challenging and authentic content that will engage the student in the learning process. This learning process is much more effective unlike the monotonous monologue classroom situation in which the teacher just lectures from a raised platform while the students just focus to him or her. Learning approaches using contemporary ICTs offer many opportunities for constructivist learning with their provision and support for resource - based student- centred settings and by letting learning to be related to context and to practise (Berge, 1998; Barron, 1999; Amin, 2012).

Two decades away the move away from traditional teaching to use of ICT in mathematics lessons has been worrisome for many countries. Correct and effective classroom use of ICT is scarce (e.g. Office for Standards in Education [Ofsted] 2001). Established curricula and teaching methods remain in place under a thin coating of technological glitter, and there is often an underutilization of technology and poorly integrated into classroom practice. The latest Third International Mathematics and Science Study surveys Martin et al(2000: 239), Mullis et al. (2000, 218) found that at least 10% of students reported frequent use of computers in their lessons in both subjects only in Israel and the US. National teacher surveys paint a similar picture. In the US, the combined data from three surveys showed that only half of the teachers who had access to computers used them in their classes (Smerdon et al. 2000, as cited in Hennessy et al., 2005).

ICT gives the teacher a suite of representation tools for presenting information to the students just like the blackboard or whiteboard that help the teacher draft ideas, to present rules and concepts and to diagram information. With only one computer in a classroom, a digital projector connected to the teacher's computer helps the teacher to present information on a large projection screen, on a large - screen television monitor or a white wall, facilitating the whole class discussion and participation. Also, a scan-converter connected to the teacher's computer, and a television gives the opportunity to present and look at information on a television screen (Deirdre, 2003).

The students will mostly benefit with the analytical, creative and collaborative power of computers to map out and analyse assumptions, present ideas and participate in projects with their peers locally and internationally. ICTs have the potential to play a powerful role in enhancing the tools and environment of learning and thus preparing students to gain skills, competencies, and social skills necessary for competing in the emerging global "knowledge" economy (Ministry of Education, Science and Technology, Government of Kenya, ICT in education options paper, 2005).

There is evidence that ICT application to the core business of education can speed up and improve learning in several ways, from basic skills (Mann, 1999; BECTA, 2000); problem solving (Oliver and Omari, 1999; Williams, 1999), information management Peabody(1996), work habits Adnanes (1998), motivation (US Congress, 1995; Allen, 2000; Combs, 2000; Diggs, 1997; Sherry, 2001), creating life-long learning habits Schollie (2001) and concept development Yelland (1998). Multimedia allows us to represent and experiment in a 'virtual' world – transferring control and concept to students in new forms just as an experiment allows us to reproduce, represent or test a pattern of activity in the physical world. The interactive capacity of ICTs gives students ample time to engage as creators and manipulators in the learning process (Dellit, 2003).

ICT can be used as a pedagogical tool. The proponents of ICT integration into the curriculum assume that ICTs will improve instructional practices and students' performance (Finger et al., 2007; Guven, 2008; Herbert and Pierce, 2008; Nabbout and Basha, 2000). The use of ICT can improve students' negative attitudes towards education. Mathematics experiences low performance at all levels of schools in the Botswana curricula, although it is one of the core subjects. The students are facing problems in learning mathematics because of their abstract nature. The representation of mathematical ideas and concepts in a visual way, which is faster and easier to comprehend, can be achieved by the use of ICT (Garegae and Moalosi, 2011).

Research findings encourage the education system to embrace ICTs in the era of this world phenomenon. In mathematics education there is an encouragement of use of ICT based on objectives for Education For All (EFA) and Millennium Development Goals (MDGs). The students cannot make connections between concepts in mathematics teaching because of abstract and mind-numbing in a traditional teaching approach. Most students become disinterested and perform badly in mathematics. Batswana students had been performing badly at national and international levels as compared to other countries globally. The above mentioned gaps can be closed with the use of technologies. The students can be relieved from tedious calculations with the use of computers and graphing calculators when given enough time to concentrate on concepts and reflect on problem- solving processes (Chakalisa,et al., 2010).

Technology incorporates the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. Technology can change how people access, gather, analyse, present, transmit and simulate information. A powerful learning environment and the transformation of teaching and learning process in which students deal with knowledge in an active, self-directed and constructive form is by the use of ICT (Volman and Van Eck, 2001). ICT is not just viewed as a tool to be added or used as a replacement of current teaching methods, but is seen as an essential instrument for supporting new forms of teaching and learning. Development of students' skills for cooperation, communication, problem-solving and lifelong can be gained with the use of ICT (Plomp et al., 1996; Voogt, 2003). Skills for searching and assessing information which are of importance in the preparation of the students for the knowledge society can be gained through technology as a tool to support the educational

objectives (Drent and Meelissen, 2007). Innovative use of ICT can facilitate student-centred learning (Drent, 2005). Therefore, every teacher in every subject should use learning technologies to enhance their students' learning. These technologies can engage the students' thinking, decision making, problem-solving and reasoning behaviours (Grabe and Grabe, 2001). These are cognitive behaviours that students need to learn in an information age.

The computer as a classroom tool has captured the attention of the education community. This useful instrument can store, manipulate, and retrieve information. The computer has the capability of engaging students in instructional activities to increase their learning and also assist them in solving complicated problems to enhance their cognitive skills (Jonassen and Reeves, 1996). The teachers are regarded as at the centre of curriculum change and in control of the teaching and learning process. Therefore, they must be able to prepare young people for the knowledge society in which the competency to use ICT to gain and process information is very vital (Plomp et al., 1996 as cited in Afshari, Bakar, Luan, Samah and Fooi, 2009).Hand-held calculators have been mostly used globally since the early 1970s in mathematics teaching in educational systems. Several studies have revealed that the use of calculators can enhance students' ability to learn basic facts. The students who most frequently used calculators displayed more advanced concept development and problem solving than those who did not use them (Cockroft, 1982; Suydam, 1982; Howson, 1991; Hembree and Dessart, 1992, as cited in Kaino and Salani, 2004). These studies reduced fears that calculators could affect students' mastery of computational skills attained from traditional paper-pencil methods (NCTM, 1974; Cockroft, 1982, as cited in Kaino and Salani, 2004).

There was availability of digital technologies in school mathematics classrooms with introducing simple four-function calculators since the 1970s. Since then, computers were equipped with sophisticated software, graphics calculators that have changed into 'all purpose' hand-held devices. These hand-held devices integrated graphical, symbolic manipulation, statistical and dynamic geometry packages. The web-based applications offered virtual learning environments that have changed the mathematics teaching and learning environment. Mathematical knowledge is not fixed but fluid, constantly being created during students' interaction with ideas, people and their environment. When technology is part of this

environment, it becomes more than a substitute for mathematical work done with pencil and paper (Goos, 2010).

Technology can change the nature of school mathematics through engaging students in more active mathematical practices like experimenting, investigating and problem-solving, which bring depth to their learning and encourage them to ask questions instead of only for answers (Farrell, 1996; Makar and Confrey, 2006). Olive and Makar(2010) argue that mathematical knowledge and mathematical practices are inextricably connected, and this connection can be improved with the use of technologies (Goos, 2010).

The students will require ICT knowledge, skills, and awareness for them to be successful in future. The country's economy will depend on a high level of ICT competence from its people to be technologically developed and internationally competitive (Motshegwe, 2005). Several educational studies in a couple of years have shown the importance of ICTs in mathematics instruction for countries that have integrated technology into their curricula. The importance of ICTs in most areas in teaching and learning is building a conceptual understanding of core content, addressing misconceptions, fostering inquiry and investigation, applying knowledge and skills to interdisciplinary challenges, creating and transforming knowledge for meaningful purposes and collaborating with others (Maximizing the Impact, 2007, 9-10, as cited in Chakalisa, et.al.,2010).

Indeed, computers have a positive effect on learning and are motivating for students (Reeves, 1998). Most teachers are in favour of computers than other technologies and also administrators, parents, politicians and the public widely support their use. Reeves(1998) states that computer-based cognitive tools like databases, spread sheets, communication software have been developed to work as intellectual partners to enable and facilitate critical thinking and higher order learning (Motshegwe, 2005).

The skills of locating, evaluating and using information from a wide range of sources create the Information Skills which are needed for people to be information literate, allowing them to engage in effective decision making, problem-solving and research. Therefore, the importance of ICT cannot be over emphasized as it offers the education process one of the most potentially powerful learning tools available. Computers can support learning across the whole curriculum and communication networks can provide the student with fast and searchable access to vast amounts of information. It also supports a wide range of educational objectives, including independent learning, collaboration with others and communication skills (Hunt, 2004). Therefore, it is of importance that all school going children have enough access to ICT and that they develop the skills, taking advantage of the learning capabilities that ICT offers (Motshegwe, 2005).

Supporters of constructivist learning theory Sheppard (1995); Turker (1993) have stressed the need for students to actively construct knowledge for themselves, engage in cooperative problem solving and gain skills learned in real problems. There is little change in the schools about quality of teaching and there is negligence of important strategies. It is almost a decade since different reforms were introduced in Botswana's education system. The teaching in schools is still didactic and authoritarian with little or no recognition of the students' ability to actively construct knowledge. Several reasons have been stated to explain this lack of change as lack of resources, poorly trained teachers, large classes and an examination-driven (high stake) system. Turker (1993) argues that students should be involved in exercises they have to apply mathematical information and reasoning to circumstances same to their real-life situations or estimate how mathematicians do their work. The focus involves helping students to become more self-directed in their learning plans and activities. The learner-centred model encourages teachers to see their students as academic partners working together to produce appropriate and meaningful learning experiences. It needs teachers who will change their standard teaching approaches (Raboijane, 2005).

Today's world technology has become a vital tool that can be used in various forms to improve and enhance mathematics learning. According to NCTM (2000) technology can facilitate mathematical problem solving, communication, reasoning, and proof; and it can also provide students with opportunities to explore different representations of mathematical ideas and support them in making connections within and outside of mathematics (NRC, 2000, as cited in Kaino, 2007). Graphing calculators have often been considered as enhancing mathematics education because the students can use them for algebraic symbol manipulation. Most of the skills students learn symbolically like factoring complex polynomials to figure out the roots are more taught by working with the graphs of the functions. Simple models like population growth can be built and run on these calculators. Most of the programs that a few years ago were run on microcomputers can be captured on personal, portable, affordable technology. Palm Pilots are a latest example of these personal aids; one of the most fascinating usages of these hand-held computers is as a data collection device that can go where the student goes rather than being, instead of being stuck in a classroom (Rubin, 2000).

Roschelle, Tatar, Shechtman, Hegedus, Hopkins, Knudsen and Stroter (2007) concurred with Rubin (2000), that in mathematics education calculators are connecting graphing and algebraic symbols and enhance algebra learning. Imison and Taylor (2001) as cited in Simelane (2013) argue that ICT enhances ability to think, learn, to communicate, use the brain creatively and logically and provide the means by which one search out huge stores of up-to-date, relevant and archive information. This highlights the main advantages of using ICT in the classroom, providing teachers with a tool for research and communication and increased productivity and problem-solving in their classrooms (Barron, Kemker, Harmes and Kalaydjian, 2003, as cited in Simelane, 2013).

More than a decade ago, some argued that using ICT in the mathematics classroom provides sufficient learning opportunities for the students. ICT allows students to learn from feedback. The computer always offers a quick and appropriate feedback that is non-judgmental and impartial. This can encourage students to make their own conjectures and to test out and change their ideas. The ICT (e.g. computers and calculators, allows students to produce many examples when exploring mathematical problems. This supports their observation of patterns and

the making and justifying of generalisations. ICT assists students to see a pattern and connections. The computer allows formulae, tables of numbers and graphs to be linked readily. Changing one representation and seeing changes in the others assists students to understand connections between them. Using ICT permits students to work with dynamic images impossible to be done within traditional teaching. With the use of computers, students can manipulate diagrams. This encourages them to visualise the geometry as they generate their own mental images. Using ICT (e.g. computers) allows students to work with real data that can be represented in various forms. This supports interpretation and analysis that lead students to higher order thinking skills (Wahyudi, 2008).

Twining (2002) distinguishes between three categories within the learning tool focus. Computers can be used to support, extend or transform learning as suggested below: Computers support learning when the content to be learnt and the process of learning remain the same, but some processes are made more efficient or more effective through the use of computers. For example, using a calculator or spread sheeting program to perform multiplication as part of solving a problem makes the lower order processes that support problem solving more efficient; Computers extend learning when the content and/or the process of learning is changed and this change could have been made without the use of computers (Lynch, 2006).

The NCTM (2000) gives an example of what Twinning's framework would see as extending learning: using a graphing facility, "students can examine more examples or representational forms than are feasible by hand, so they can make and explore conjectures easily" (NCTM, 2000, np). This example of computer use extends learning by facilitating a conceptual (in contrast to procedural/technical) approach to teaching and learning than traditional pen and paper methods. This computer use changes the focus of the content, but the same focus could be achieved without the use of a graphing program; Computers transform learning when the content and/or learning are changed, and these changes could have not happened without the use of computers. For example, a multimedia authoring program can be used to create, and to explore, dynamic systems graphically in ways that would be difficult to achieve without the use of computers (Lynch, 2006).

ICT has changed the means by which we inform ourselves; remain up to date with world events and areas of personal interest and further learning. The majority of people do not depend on books and journals as the first or primary sources of information or learning. We depend entirely on images, video, animations and sound to gain information and to learn because of increased and improved access to the internet (Hedges, Konstantopoulos and Thoreson, 2000).

ICTs had a positive influence on education, which affected teaching, learning and research (Yusuf, 2005). ICTs can accelerate, enrich and deepen skills, motivate and engage students and help relate school experience to work practices. They create economic viability for future workers and also strengthen teaching and helping in changing schools (Davis and Tearle, 1999; Lemke and Coughlin, 1998, cited in Noor-Ul-Amin (2012). Research has shown that majority of teachers do not make use of the capability of ICT to contribute to the quality of learning environments although they value this potential significantly (Smeets, 2005). Harris (2002) case studies on three primary and three secondary schools which concentrated on innovative pedagogical practices ICT inclusive, concluded that the advantages of ICT will be attained when confident teachers are eager to explore new opportunities for changing their classroom practices with the use of ICT. Using ICT will enhance learning environments and will also prepare the next generation for future lives and careers (Wheeler, 2001), as cited in (Noor-Ul-Amin, 2012).

Eze and Olusola (2013); Castells (2000) affirm that ICT in the classroom are important for provision of opportunities that let students operate in the information society because the traditional methods do not prepare the students to be productive. Teachers of today also encounter a challenge of teaching ‘the Net Generation’ coming to class well equipped with many skills are always in touch, motivated by and responding to the ever changing worlds. These students can use any technology that comes across. Therefore, teachers need to change their attitudes and beliefs in their teaching activities and adopt technology to perform the pedagogic activities without difficulties and confidence (Mathipa and Mukhari, 2014).

Research studies Eze and Olusola (2013) also show that teachers use ICT to expand available pedagogical resources and to facilitate sharing of knowledge with fellow teachers. As far as ICT assists students in completing their educational tasks, ICT also gives teachers the opportunity to assist students with particular needs. Tedla (2012) and Tay et al. (2012) confirm that teachers use ICT tools to make the lessons more interesting and engage students according to students' capabilities. Using different digital tools also encourages students to reinforce the learnt material using individual learning styles. It is also beneficial to students from digitally poor backgrounds because it provides them with the opportunity of being included in using ICTs for knowledge sharing and global communication with anyone, anytime and anywhere (Mathipa and Mukhari, 2014). Hennessy, Harrison and Wamakote (2010, p.41) assert that most Nigerian teachers using new technology in teaching and learning insisted that ICT is very useful and make teaching and learning easier (Mathipa and Mukhari, 2014).

The technological tools like computers and calculators can replace the present traditional mathematics teaching for more meaningful problem-solving and graphing opportunities and giving new possibilities in the teaching and learning of mathematics. Technology is regarded as a catalyst for transformation for mathematics education (Dunham and Dick, 1994:440; Heid, 1997:5; Heid, 1998), as cited in (Gebrekal, 2007).

Computer technology lets students' variations of linked approaches to the same problem situation and allows the formation of linked multiple-representations of mathematical concepts Heid (1998); Waits and Demana (2000), and to graphically explore, estimate and discover them, and to approach problems from a multi-representational perspective (Hennessy et al., 2001:283; Hollar and Norwood, 1999, p.222). Beckmann et al. (1999:451); Confrey (1992:150); Fey (1989; p.255) and Heid (1998) state that students explore the concepts and notion of functions in multi-representational (symbolic, numeric, tabular and graphic or visual) modes with the use of computer technology. The students can also use computer technology to make connections between mathematical ideas Smith and Shotsberger (1997) between a real-world phenomenon and its mathematical representations and between a student's everyday world and his/her mathematical world (Heid, 1998), as cited in Gebrekal (2007).

Dick, Wilson and Krapfl in Beckmann et al.(1999; p.451); Heid (1998) and Hennessy et al. (2001,p. 283) argued that the use of multiple representations, interpretation from one representation to another, and the analysis requesting interplay among graphic, numeric and symbolic information are significant for comprehending functions. A student making links between mathematical ideas makes a deeper understanding of those ideas and a range of representations of the problem, allowing the student to present the problem in a way that best makes sense to him/her (NCTM, 2000).

The students can gain experiences of constructing mathematical concepts with the use of computers and calculators, which are important technological tools. There is a different way of stressing mathematical concepts in a technological atmosphere unlike in a traditional mathematical instruction that encompasses frequently long and time consuming algorithmic computations. Rote learning procedures are mostly being used in traditional teaching class time. The instruction can change to concept development and problem-solving in the technological rich environment by focusing on concepts because these tools get rid of long and time consuming routine task (Branca, Breedlove and King, 1992; Fey, 1989; Hennessy et al., 2001; Wheatley and Shumway, 1992), as cited in (Gebrekal, 2007).

According to Shadiq et al.(2010) not all schools in Indonesia have integrated ICT in the teaching and learning of mathematics because of facilities and geographic problems (especially rural and remote area). The findings by Yadar (2007) and UNESCO (2008) state that a well-handled object practically impresses itself more firmly in the mind unlike the object seen from a distance or in an illustration. Yadar (2007) further stated the course is regarded as incomplete in Science and Mathematics if no use of practical work because we learn by doing. Thus, practical work is very important at the school level, especially in any science and mathematics course (UNESCO, 2008), as cited in (Yara and Otieno, 2010). Psacharopoulos and Loxley cited by Lauglo and Maclean (2005) stressed that practical subjects can allow the students to learn from more active doing than what is typically in academic subjects. Mathematics can be practical and fascinating if there are mathematics laboratories whereby some theories and theorems in the subject can make it more practical. By the use of ICT, this can be achieved (Yara and Otieno, 2010).

Jones (2004) affirms that seven obstacles are found in integrating ICT into a lesson as: (i) teachers lack of confidence during integration, (ii) inaccessibility to resources, (iii) No time for the integration, (iv) no effective training, (v) faced with technical problems during the use of software, (vi) no personal access during lesson preparation and (vii) the age of the teachers. Keong, Horani and Daniel (2005) in their study of 111 teachers found six main obstacles encountered by teachers in ICT implementation into their mathematics classroom. There was no time in the school schedule for projects involving ICT (54.6%), insufficient teacher training opportunities for ICT projects (40.8%), inadequate technical support for ICT projects (39.2%), lack of knowledge on integrating ICT to enhance the curriculum (38.8%), integrating and using various ICT tools in a single lesson (36.8%) and inaccessibility to the required technology at homes of students (33.0%) (Wahyudi, 2008).

Urban and rural areas have differences regarding ICT infrastructure. Accessibility to a reliable supply of electricity is regarded ICT infrastructure. Accessibility to a reliable supply of electricity is challenging but hardly hit in rural areas because of difficulties connecting to national electrical grids. There is insufficient human resource capacity to give ICT training and equipment servicing. There is also a lag between the availability of ICT infrastructure and the ability of agrarian societies to integrate it to benefit national development. African schools and universities experienced use of second-hand and refurbished PCs got from groups like Computer Aid International, Digital Links and World Computer Exchange (Farrell and Isaacs, 2007).

Okiy (2005) argues that poor and inadequate telecommunication facilities; poor level of computer literacy, even within the academic community; poor level of computer facilities; poor level of awareness of Internet facilities among policy makers, government officials and the ruling class; and minimum involvement of academic institutions in network building in Africa are challenges affecting the use of ICTs (Haliso, 2011). The rate at which computers are being used in the mathematics classroom is a concern, although there are a growing number of computers in schools. Much effort has been made to use them in the teaching and learning of mathematics. These concerns are classified into three areas: marginally used of computers in mathematics classes; integration of computers progresses slowly, and where computers are used, teachers

often used them in whole class teaching instead of being used by students (Oye, Shallsuku and Iahad, 2012).

According to Coben, D. et al. (ed., 2000) technologically advanced countries differ from their Third World counterparts who totally depend on agriculture. The three- year secondary school syllabi recommended mathematics teaching and learning to be learner-centred by using various learner-centred approaches like exposition and consolidation, discussions, practical work, problem solving and investigative work. Graphic calculators and computers should be used during the teaching and learning of mathematics for giving joy and motivation as modern technology. The Three-Year Junior Secondary Mathematics Program's mandate is for students to complete their junior level with a developed awareness of computer applications in mathematics activities coupled with developed an appreciation of technology and technological skills required in mathematics knowledge (Republic of Botswana, 2010).

2.4 Barriers and challenges to ICT use in the teaching and learning of mathematics

The rapid growth of information and communication technologies (ICT) has drastically reshaped teaching and learning processes. Mathematics teachers are faced with inhibiting challenges or barriers to computer use (Hudson and Porter, 2010). Integrating new technologies into everyday teaching and learning of mathematics has proven to be a slow process that involves multiple challenges for teachers and students Hohenwarter and Lavicza (2007, p.49). Despite the considerable promise that technology provides, there are barriers stopping the realisation of this (Curri, 2012). Mumtaz (2000) and Roszell (1995) support other studies that lack of time is a hindrance to teachers that stops them from using computer technology. According to Roszell (1995) time is a major hindrance in the use of computer. Teachers are reluctant to use computer technology because it can shorten learning time for students. The actual time spent for teaching and learning is inadequate for teachers and this may stop them from using computer technology (Gilakjani, Sabouri, and Zabihniaemran, 2015).

According to a study conducted by the 1999 National Centre for Educational Statistics on teacher quality in the USA, only 20% of teachers felt very prepared to integrate technology into their teaching. Different reports considered equipment, software time, and training as the most common barriers to integrating technology (Hall, 1997). Teachers during their pre-service education might not have had the training and experience in using technology (Ponsessa, 1996; Loveless, 1996).Teachers must have sufficient access to working computers (or other technologies) and sufficient technical support(Dexter, Anderson, and Becker, 1999 cited in Kgalemang, Leteane, Moakofhi, Pholele, and Phiri, 2015).As less technologically advanced countries joined the programme in 1999-2000, they encountered main barriers of ICT use in classes like lack of computer hardware (60%), software (56%), and reliable internet connections (52%), especially in African countries like Mauritania, Ghana and Zimbabwe(Hennessy et al., 2010).

According to Snoeyink and Ertmer, (2001), as cited by Wachira and Keengwe, 2010) teachers face challenges because of barriers that can be classified as either external or internal barriers. Banks (2000) stated that teaching is a lively process whereby person shares information and ideas to make behavioural changes. According to Silva, Cahalan, and Paquet (1998), barriers, constraints, deterrents, impediments, or obstacles are factors that inhibit or stop people from partaking in activities. Brown et al.(1988) stated that students believe that mathematics is important, difficult, and based on rules. Kenny and Silver, 1997, as cited in Bergeson, Fitton, Bylsma, Neitzel, and Stine, 2000) further stated that one out of every two students thinks learning mathematics should be above all memorisation. Science and mathematics were often described as difficult subjects Smart and Rahman (2007). Thus students barely choose science streams (Lutfuzzaman, Muhammad and Hasan, n.d; Mojumder, 2009, as cited in Pia, 2015).

Researchers identify various kinds of factors impeding the usage of ICT in the classroom. Sang et al., Tedla, 2012 and Tay, 2011) state that there are two types of barriers inhibiting the integration of ICT in teaching and learning as school characteristics or external barriers and teacher characteristics or the internal barriers. The school characteristics are factors that are perceived as main obstacles and include inadequate access to ICT, internet connectivity, technology related training, ICT policy and time while the teacher characteristics embrace

teachers' beliefs, confidence, ICT skills and teachers' attitudes towards ICT (Tay et al.: 2012; Tedla, 2012, cited in Mathipa and Mukhari, 2014). There are many factors impeding the usage of ICT in the teaching and learning of mathematics in the classroom setting but the researcher will consider: Lack of accessibility to ICT, Lack of time, Lack of effective training and Lack of technical support.

Most Junior Secondary Schools (Grades 8 to 10) have computers or computer laboratories, but not all schools are equipped with these resources (Masole, et al., 2006). Some schools do not have internet connectivity because of lack of electricity. Using calculators is in eighth grade because the mathematics and science syllabi encourage the use of technology. The aims of the three-year integrated science and mathematics are for development of an awareness of computer applications in mathematics activities.

Through my personal experience as a mathematics educator and researcher, most of the classroom interactions are teacher-centred and examination driven. 'Rote learning' prevails in learning activities where students have to memorise formulae without comprehending them and their applicability.

2.4.1 Lack of accessibility to ICT

A basic factor in using of ICT is sufficient computer labs and ICT equipment. This is for easy access to ICT tools when needed by subject teachers Hennessy, Ruthven, and Brindley, (2005). Lack of adequate ICT equipment and internet access is problematic that schools especially in rural places are facing now. For example, results of a study show that in Kenya, some schools have computers but this could be limited to one computer in the office only. Even those schools with computers, the student-computer ratio is high. The report continues to show that the schools with ICT infrastructure are supported by parents' initiative or community power (Chapelle, 2011, cited in (Ghavifekr and Rosdy(2015).

The use of computers in mathematics has increased tremendously in some settings, while in others not much change has occurred at all. Students' access to technology in many secondary school mathematics classrooms is very limited or non-existing in most countries Kissane and Kemp(2013). In the industrialised world and in many parts of the developing world, especially in commerce and industry, different technologies are widely available to most people. Although there is a widespread presence of technology but it seems in East Asia; Taiwan, China, Japan and Korea, technology is not widely used in secondary mathematics teaching and learning Kissane and Kemp(2013). Introducing technology into schools depends upon availability and accessibility of ICT resources (e.g. hardware, software and communications infrastructure). A study conducted by Agyei and Voogt (2012) in Ghana among pre-service and in-service Mathematics teachers, reported low levels of ICT integration levels because of access levels of ICT (Amuko, Miheso, & Ndeuthi, 2015).

Lack of access to ICT and lack of internet connectivity is a barrier. Computers in some Nigerian schools are shared and therefore need to be booked well in time. Teachers who do not or forget to make the bookings were denied access to those computers (Hennessy et al., 2005).Lack of educational hardware is also a barrier to stopping teachers and students from using ICT in teaching and learning. Eze and Adu(2013) affirm that lack of electricity in rural schools and high cost of computers is a hindrance to integrating ICT in Botswana. Internet connectivity is still impossible where there are no telephones and electricity. Kort and Husing (2007) found that a third of European schools do not have broadband internet access Mathipa and Mukhari (2013).

A recent survey has revealed that only one-third of teachers feel prepared to use ICT effectively although ICT is creating opportunities for necessary changes in the way teachers teach and the way students learn. This includes being able to use word processing, spread sheet, presentation and internet browsing software. Such tools help teachers to prepare reports or lesson plans, take notes, and communicate with colleagues and parents that lead to their productivity being increased. These basic skills are essential but require teachers to be conversant with ICT tools and materials in the subject they teach. They must also be able to incorporate these

resources into classroom activities that accomplish important learning goals (Williams, Mehlinger, Powers and Baldwin, 2002).

Evidence shows that although teachers have had increasing access to computers for instruction but a few of them use them. For example, in 1996, the National Association reported that while 84 per cent of all public school teachers said personal computers were available to them but only around 60 per cent showed that they ever used (U.S. Census (1998). In South Carolina a survey of middle school mathematics and science teachers had shown that although 70 per cent of these teachers had access to computers but only almost half of those with access did not use them Dickey and Kherlopian (1987) as cited in Hedges, Konstantopoulos and Thoresan (2000). Technology is poorly integrated into the classroom curriculum and is under-used despite being widely available (Maddux, Johnson, and Harlow, 1993; Becker, 1991; Ognibene and Stiele, 1990, as cited in Hedges, Konstantopoulos and Thoresan, 2000).

Kerr's (1991) interviews and observations with American teachers who had successfully incorporated technology into their practice had revealed that 'obvious and dramatic' changes in the classroom organisation and management occurred because of technology usage. The students' access to technology at school and home has enormously increased over the last few years, mainly in the US, Australia, and Great Britain and, to a lesser degree, in other economically advantaged nations (particularly Finland, New Zealand and Sweden: OECD 2000, ch.4). A couple of governments' initiatives have helped dramatically increase the importance of ICT. Recent examples of ambitious infrastructures created to provide access to on-line learning resources include Sweden's 'School net', the 'Virtual Agency' in Japan (OECD 2000, ch.9), and the National Grid for Learning scheme in the UK. The latter is one of the various ICT initiatives on which the British government has spent 1.8 billion pounds since 1997. Governments have included extensive training schemes for all new and existing teachers in using ICT in subject teaching and learning in these initiatives (Hennessy, Ruthven and Brindley, 2005).

It is rare to find correct and effective classroom use of ICT (e.g. Ofsted, 2001). Established curricula and teaching methods remain in place under a thin coating of technological glitter, and normally existing technology is underutilised and poorly integrated into classroom practice. For example, the recent Third International Mathematics and Science Study [TIMMS] surveys(Martin et al. 2000: 239, Mullis et al. 2000: 218) found that at least 10% of students reported frequent use of computers in their lessons in both subjects in only two countries of Israel and the US. National teacher surveys share the same sentiment. Combined data from three surveys in the US had revealed that only half of teachers with access to computers used them in their lessons (Smerdon et al., 2000). Similarly, about half of English secondary schools reported 'substantial use' and half reported 'little use' within the three core subjects at the time of the study (DFEE 2000), as cited in (Hennessy et al., 2005).

Several research studies had shown that lack of access to resource including those at home is another hindrance that discourages teachers from integrating new technologies into education and especially into science education. Sicilia's (2005) study, teachers complained about the problem they always encountered to access computers. The reasons for inaccessibility of computers were: "computers had to be booked in advance and the teachers would forget to do so, or they could not book them for several periods in a row when they wanted to work on several projects with the students" (p.50). In a nutshell, teachers shared ICT materials, which led to inaccessibility of those ICT materials individually by teachers. According to Becta (2004), the accessibility of ICT resources is not frequent because of non-availability of the hardware and software or other ICT materials in the school (Becta, 2004).

Empirica (2006), in European study found that lack of access is the most hindrance and teachers reported various hindrances to using ICT in teaching like lack of computers and lack of adequate material. Korte and Husing (2007, p.4) also found some infrastructure barriers, like lack of computers and lack of adequate material. Korte and Husing (2007, p.4) further found that some infrastructure barriers are unavailability of broadband access in European schools. They concluded that one third of European schools are still with no broadband internet access. Pelgrum (2001) explored practitioners' views from 26 countries on what were the main obstacles to implementing ICT in schools. He ascertained that four of the top ten barriers were linked to

the accessibility of ICT. These barriers were insufficient numbers of computers, insufficient peripherals, insufficient numbers of copies of software, and insufficient simultaneous Internet access (Bingimlas, 2009).

According to Toprakci (2006), unsuccessful implementation of ICT into science education in Turkish schools is because of low numbers of computers, oldness or slowness of ICT system and scarcity of educational software in school. Likewise, Al-Alwani (2005) found that no accessibility to the internet during the school day and lack of hardware were hampering technology integration in Saudi schools. Current research had shown that one of the most obstacles to technology integration in the classroom on the Syrian schools were insufficient computer resources (Albirini, 2006, as cited in Bingimlas, 2009).

Gomes (2005) argues that lack of infrastructure and lack of suitable material resources are barriers. Balanskat et al. (2006) state that the accessibility of ICT resources does not lead to its successful implementation in teaching, and this is not only because of the lack of ICT infrastructure but also due to other barriers like lack of high quality hardware, suitable educational software and access to ICT resources. Cox et al. (1999a) found that most teachers agreed that insufficient ICT resources inhibit teachers from using ICT in the school. According to Osborne and Hennessy (2003), the limitations on access to hardware and software resources had a negative effect on teachers' motivation to use ICT in the classroom (Bingimlas, 2009).

2.4.2 Lack of time

Teachers experience problems for finishing given tasks because of lack of time for them and teaching ICT is an area that is highly affected by this. Fabry and Higgs (1997) state that time is needed in any profession to learn new skills but teachers have insufficient time left after spending most of their day teaching. Most of their time is taken by other commitments like liaising with parents and attending staff meetings. They do need that time to experiment with the technology, share their experiences with colleagues, and attend technology related in-service training programmes (BECTA, 2003).

Manternach-Wigans et al (1999) state that teachers are worrisome about lack of time for technology; they feel that they need abundant time to learn computer basics, plan how to integrate technology into their lessons, and actually use technology in the classroom. According to Preston et al. (2000), teachers felt more work is required in preparing accurate ICT materials to be used by students of mixed abilities, and complained of lack of time restricting them from exploring materials for potential usage with ICT(BECTA, 2003).Cuban et al. (2001) conquered with this study because in their survey of teachers at two American high schools, it was found that there was insufficient time for computers to be fully incorporated into daily teaching .Teachers were of the view that they would require more hours to preview web sites, prepare multimedia materials for lessons, and to embark on training. In the same study it was found that this problem did not apply to only those teachers who made little use of ICT but also teachers who were attempting to make full use of the technology in their lessons were also affected because they were to work longer hours in order to make their ICT use successful resulting in them being tired (BECTA, 2003).

Many recent studies show that teachers little use technologies because of inadequate time, although most of them are competent and confident in using computers in the classroom. Various researchers identified time limitations and the difficulty in scheduling in their teaching enough computer time for classes as a barrier to teachers' use of ICT (Al-Alwani, 2005; Becta, 2004; Beggs, 2000; Schoepp, 2005; Sicilia, 2005). According to Sicilia (2005), most common challenge reported by all teachers was a lack of time to plan for technology lessons, explore the different internet sites, or look at various aspects of educational software. Cox et al. (1999a) found that insufficient time to review software inhibits teachers from using ICT in the school (Bingimlas, 2009). Most Kenyan teachers considered lack of time as one of the most problematic factor to technology utilisation in schools and they stated that time is needed in mastering technology (Kukali, 2013).

Wood, et al. (2005), cited in Petrov (2014) concurred with Kukali (2013), in Amuko et al.(2015) that lack of time to plan classes using these new technological tools or to explore new tools in your own free time to understand their functionality is a common problem. Although time management is always an issue in planning or learning new things, understanding these technological tools and being able to use them may help the teachers facilitate their own classroom management and class preparation later on (Petrov , 2014).

Lack of time because of tight schedules was a barrier affecting the application of ICT in Saudi Arabia because teachers there work from 7.00 a.m. until 2.00 p.m (Al-Alwani, 2005). Teachers and students in Saudi Arabia have an insufficient number of hours during the day to work on integrating ICT into science education. Sicilia (2005) also concluded that teachers in Canada take more time to design projects including the use of new ICT than to prepare traditional lessons. Sicilia (2005) interviewed teachers who commented that "the constraints of different class schedule contributed to the lack of time they spent together to work on planning classroom activities" (p.41). Supporting this finding, the most significant constraint on use quoted by 86-88% of primary and secondary science teachers surveyed by Dillon, Osborne, Fairbrother, and Kurina (2000) was a lack of time as cited in Osborne and Hennessy (2003, p.37). However, Gomes (2005) concluded that a lack of time needed was one of the main reasons for science teachers not to use ICT in the classroom to accomplish plans (Bingimlas, 2009).

It takes a considerable amount of time to source and evaluate suitable ICT based and interactive material. The average day of a teacher is busy and often it is unfeasible for teachers to dedicate the required time to dealing with the increased workload technology use can bring (Dunleavy, 2007, Hew and Brush, 2007, Silvernail 2004, Cuban et al., 2001, cited in Sloyan, 2011). Sloyan (2011), argues that teachers remain occasional or non-users regardless of the equipment at their disposal. Furthermore, Marshall, Elgort and Mitchell (2003) maintain that staff continues to identify the lack of time as a barrier to the use of technology. They further stated that the biggest barriers to the use of computers identified by teachers participating in the 1998-1999 survey assessing World Links schools programme were lack of time in classes and daily school activities instead of physical resources like hardware, software, electricity in schools (Kozma, McGhee, Quellmalz, and Zalles, 2004, 376, cited in Hennessy et al., 2010).

2.4.3 Lack of effective training

Even with adequate technology access, effective professional development remains a reason that makes it difficult to increase the level of technology integration in classrooms. Research indicates that simply providing teachers with professional development opportunities related to using technology does not translate into higher levels of integration in the classroom. It is only when they are provided the knowledge, skills, resources, and support that they will integrate technology in the curriculum to maximize its effects on teaching and learning (Papanastasiou, Zemblyas, & Vrasidas, 2003) cited in Harrell and Bynum.

Teachers' readiness and skills in using ICT are vital in using ICT in education. The teachers require adequate ICT skills to implement the technology and to be highly confident in using ICT tools in the classroom setting. According to Winzenried, Dalgarno and Tinkler (2010), teachers who have undertaken ICT course are more effective in teaching by usage of technology tools unlike those that have no experience in such training. A school in Ireland reported that teachers who did not develop sufficient confidence avoided using ICT. A similar case occurred in Canada because teachers were worried that their students knew more about the technology than they did (Hennessy et al., 2005, cited in (Ghavifekr and Rosdy, 2015).

Lack of effective training is considered a major hindrance to the use of ICT tools (Albirini, 2006; Balanskat et al., 2006; Beggs, 2000; Ozden, 2007; Schoepp, 2005; Sicilia, 2005; Toprakci, 2006). Pelgrum's (2001) findings had shown that teachers' inadequate training opportunities in using ICTs in a classroom setting study's finding was a hindrance. Equally, Beggs (2000) found a lack of training as among the top three barriers to teachers' use of ICT in teaching students. Turkey's research found in science the main problem with implementing new ICT was the insufficient amount of in-service training programmes for science teachers (Ozden, 2007). Toprakci (2006) concluded that in Turkish school's limited teacher training in using ICT is a barrier. A study conducted by Hudson and Porter in New Zealand and Australia found that one barrier that mathematics teachers identified in failing to adopt the use of computers in the classroom is a lack of adequate professional training in using computers in mathematics instruction (Amuko et al., 2015).

Fruitful use of technology for the benefit of children depends on the teachers' knowledge and their confidence and competence in using technology. Teachers need not only learn how to use technology but they also need to learn how to apply the technology to teaching and learning. They need to know which technologies will most meet children's skills, abilities and needs Girgin, Kurt, and Odabasi (2011). Teachers attain knowledge and skills on how to use mathematics' software effectively through training (Amuko et al., 2015).

Remarkably, only few African teacher training institutions appeared to be offering pre-service ICT training (Hennessy, Onguko, Harrison, Ang'ondi, Namalefe, Naseem, and Wamakote, 2010). Little or lack of professional training in education on how to use ICT is a stumbling block. According to Tedla (2012); in-service teachers have shown that lack of training is due to lack of time because teachers have limited hours to integrate ICT in the activities. Providing pedagogical training on using ICT across the curriculum is a vital matter which will let teachers to teach 'Net Generation' who are to meet the 21st century skills and become members of the information society (Mathipa and Mukhari, 2014).

Cox et al. (1999a) research's results had shown that after teachers had attended professional development courses in ICT, they still did not know how to use ICT in their classrooms; but they just knew how to run a computer and set up a printer. They explained that the courses often do not teach teachers how to develop the pedagogical aspects of ICT but only focus on teachers gaining basic ICT skills. In line with the research by Cox et al. (1999a), Balanskat et al. (2006) had shown that inappropriate teacher training is helpless to teachers on the use of ICT in their lesson preparations and classrooms. They assert that this is because training programmes do not focus on teachers' pedagogical practices in connection to ICT but on the development of ICT skills (Bingimlas, 2009).

Becta (2004) argues that, besides the need for pedagogical training, it is still important to train teachers in specific ICT skills. Schoepp (2005) also argues that when new technologies need to be integrated in the classroom, teachers have to be trained in the specific use ICTs while Newhouse (2002) asserts that for teachers to attain suitable skills, knowledge, and attitudes in relation to effective use of computers to support their students' learning teachers, should undergo some initial training. He stressed that continuing provision of professional development is needed to maintain this appropriate skills and knowledge (Bingimlas, 2009). Ultimately, teacher training is required if they are to integrate these new tools and approaches into their teaching (Osborne and Hennessy, 2003). There are inadequate or inappropriate training results to teachers being not fully confident to carry out full integration of ICT in the classroom (Balanskat et al., 2006). According to Newhouse (2002, p.45), "teachers need to not only be computer literate but they also need to develop skills in integrating computer use into their teaching/learning programmes" (Bingimlas, 2009). On the other hand, low level of ICT skills is a common obstacle as factor stopping the use of ICTs (Haliso, 2011).

Goodrum, Hackling, and Rennie (2001), teachers are regarded as the most important factor to improve students' learning. Teachers play a vital role in helping their students to understand (Sarkar and Gomes, 2010). It is of importance for teachers to undertake access continuous professional development through in-service programmes, short-term seminars and workshops (Gezahegn, 2007, as cited in Pia, 2015). Teachers also require training in technology education by focusing on the study of technologies themselves and educational technology to support classroom teaching (Newhouse, 2002). Sicilia (2005) argues that teachers are keen to learn how to use technologies in their classrooms whereas lack of professional development was a hindrance to them from integrating technology in certain subjects like science and mathematics. Pre-service teacher education can also be vital in providing an opportunity for experimentation with ICT prior to using it in classroom teaching (Albirini, 2006). Lack of ICT based in initial teacher education is a hindrance to teachers' use of what is available in the classroom during teaching practice (Becta, 2004). The teachers where training is ineffective may be inaccessible to ICT resources (Bingimlas, 2009).

Teachers need training for proficiency in the technology and they also must be trained to change their teaching methods to take full advantage of new technology and to maximise the benefits that be derived from new technology in the classroom (Bright and Prohosch, 1995, as cited in Hedges, Konstantopoulos and Thoresan, 2000). The teachers need to be empowered with skills that would enable them to make their jobs more fulfilling and less difficult and help in school improvement and benefit the children if they do not have the necessary education (Bose and Seetso, 2016).

2.4.4 Lack of technical support

According to Shakeshaft (1999, p.4) notes, "Just because ICT is present does not mean that students are using it". The teachers need support and training to integrate ICT into the curriculum into their classrooms in a productive way in the educational setting (Hismanoglu, 2012).

In most schools, technical difficulties sought to be problematic and a source of frustration for students and teachers due to interruptions in teaching and learning process. If there is a lack of technical assistance and no repair on equipment, teachers temporarily cannot use the computers (Jamieson-Proctor, Albion, Finger, Cavanagh, Fitzgerald, Bond and Grimbeek, 2013).This will discourage teachers from using those computers for fear of those equipment failures because they are not given any assistance on these breakdowns. Türel and Johnson's study (2012) revealed that technical problems become a major barrier for teachers. The low connectivity, virus attack and malfunctioning of printers are some problems that teachers face. However, there are some exceptions in the schools of some countries, for example, Netherlands, United Kingdom and Malta whereby they regard the importance of technical support to assist teachers to use ICT in the classrooms (Yang and Wang, 2012) cited in (Ghavifekr, 2015).

Teachers need to be given good technical support in the classroom and whole-school resources if expected to overcome the obstacles stopping them from using ICT in the classroom (Lewis, 2003). Pelgrum (2001) found that primary and secondary teachers' views about one of the top impediments to ICT use in education were lack of technical assistance. In Sicilia's study (2005), teachers' major barrier were found to be technical problems which included waiting for websites to open, failing to connect to the internet, printers not working, malfunctioning

computers, and teachers having to work on old computers. “Technical barriers impeded the smooth delivery of the lesson or the natural flow of the classroom activity” (Sicilia, 2005, p.43), as cited in Bingimlas, 2009).

To Korte and Husing (2007), as cited in Bingimlas (2009), ICT support or maintenance contracts in schools help teachers to use ICT in teaching without losing time through having to fix software and hardware problems. The Becta (2004) report, stated that “if there is a lack of technical support available in a school, then it is likely that technical maintenance will not be regularly carried out, resulting in a higher risk of technical breakdowns” (p.16). Becta’s (2004) survey, most of the respondents had shown that technical faults might discourage them from using ICT in their teaching for being afraid of breakdowns of equipment during a lesson.

Broken and out-dated machines, unreliable Internet connections, uncharged batteries and incompatible software are among some problems that can arise in computer-based lessons. If these problems are frequent, the subsequent wasted class time can deter teachers from using the technology especially if sufficient technical support is unavailable on site (Hew and Brush 2007, Silvernail, 2004, Cuban et al. 2001, Fuller 2000, cited in Sloyan, 2011).Teachers often encounter problems when trying to learn new technology as the lack of technical support or knowledgeable experts that can guide them through the learning experience (Smerdon, et al., 2000). However, teachers need to be taught too, so it is the school’s duty to implement necessary professional development sessions to help teachers get acquainted with the new technology and to learn to apply these new tools to class (Petrov, 2014).

Computer breakdown causes interruptions and if there is a lack of technical assistance, then there is a likelihood of regular repairs of the computers not to be done, resulting in teachers not using computers in teaching. It will discourage the teachers from using computers due to fear of equipment failure because no one would give them technical support when there is a technical problem (Buabeng-Andoh, 2012).

Many studies have shown that lack of technical support is a hindrance to the realisation of technologies in science teaching. According to Gomes (2005), a school needs a technician in ICT integration in science teaching. If there is an unavailability of a technician, then the lack of technical support can be a stumbling block in the science teaching. Toprakci (2006) found that in Turkey the lack of technical support was one of two major barriers to the integration of ICT into science education in schools and might be considered "serious". Saudi Arabian science teachers would introduce computers into science teaching, but they believe will experience problems like technical support and access. Teachers have the feeling that irrespective of years of experience or you are a novice to the profession, technical problems generate barriers to the smooth delivery of science lessons by teachers (Bingimlas, 2009).

Based on the premise that ICT can have a positive impact on mathematics teaching and students' learning outcomes, activities based on technology have been implemented in mathematics curricula in a couple of countries(Hennessy et al. , 2005). Factors like mathematics teachers' beliefs and concerns about the adoption of this innovation, facilities, in-service teachers' training and resources might hinder the successful implementation of the innovation (Hennessy et al., 2005). The introduction and implementation of ICT in the teaching and learning of mathematics have been unsuccessful in several cases in various countries (Hennessy et al., 2005).The British Educational Communications and Technology Agency, BECTA, (2004), reported that only a few teachers integrate ICT into the subject teaching in a fruitful and constructive manner that can promote students' conceptual understandings and can stimulate higher-level thinking and reasoning (Chrysostomou and Mousoulides, 2010).

According to Cuban (1999) schools that do not have technicians are often experiencing malfunctioning of software and crashing of servers. Once the breakdowns do occur, a lack of technical support may mean that the equipment remains out of use for a longer time. An example of this mentioned by Butler and Sellbom (2002), where a burnt out projector bulb took three weeks to be replaced and delayed the progress in the school. Preston et al. (1999) provide evidence that the breakdown of equipment impedes the use of ICT in schools which result in the demotivation of students and the removal of time/ resources from other essential curriculum areas. Becta survey respondents solely agreed that schools need technical support for their

smooth running. They stated that the schools need technical back-up or expertise when things go wrong. The schools need on-site ICT manager to support teachers during lessons (BECTA, 2003).

Although technology proponents have often claimed technology will replace teachers, this has not occurred. The typical view by educators is that technology can be used effectively to supplement instruction by providing instructional variety, by helping to make abstract concepts concrete, and by stimulating interest among students. Instructional television was the focus of attention during the 1950s and the 1960s. Educational television stations continued to provide some programming (Williams, Mehlinger, Powers and Baldwin, 2002).

The computer was the next technology to capture the interest of educators. Some of the earliest work on instructional applications of computing took place in the 1950s and the 1960s, but these efforts had little impact on schools. It was not until the 1980s, and the appearance of microcomputers, that many educators and public officials became enthusiastic about computers. By January 1983, 40 per cent of all elementary schools and 75 per cent of all secondary schools in the United States used computers for instructional purposes. Most frequently, students had only limited access to computers, often in a computer laboratory and only for an hour or so a week. In 1995 the Office of Technology Assessment estimated that the optimum ratio of computers to students was five to one, and by the year 2000 the National Centre for Educational Statistics reported that there was, in fact, an average of one computer for every five students, with 97 per cent of schools having Internet connections (Williams, et al., 2002).

Technology is a part of essential tools for knowledge-based society. Technology has been pushing globalisation and changing society. Hence, it is important to prepare children, and technology should be introduced into the classroom in preparation for the changing society. Most students in East Asia have good achievement in their mathematics curriculum without innovative technology. Teachers in these countries are reluctant to use technology even if they see the importance of technology, for example, the power of visualisation and the importance of exploration. In comparison to East Asia, there are many countries in which mathematics teachers are not well prepared for teaching mathematics. Judicious technology using Ball and Stacy

(2005), as cited in Isoda (2007) is a general necessary expectation in the teaching content for the knowledge-based society when we teach students both on how to use technology and thinking mathematically (Isoda, 2007). There is a simplistic motion to use technology as an alternative to paper and pencil approach (Isoda, 2007).

Zhu, Wang, Cai, and Engels (2013) assert that innovative teaching is vital for all teachers to meet the educational needs of the new generations. They also stated that teachers' technological competency is positively related to their innovative teaching performance. They went on to say teachers need to be proficient in using ICT in their class activities to boost teaching learning process. Studies had indicated that teachers integrate ICT at lower level or a basic level (e.g., Aslan and Zhu, 2015; Somekh, 2008; Tezci, 2009). Additionally, majority of teachers neither use technology for the instructional delivery nor do they integrate it into their curriculum (Afshari, Abu Bakar, Luan, Abu Samah, and Fooi, 2009).According to (DeCorte, 1990; Becker, Ravitz, and Wong, 1999; Pelgrum, 2001; Becta, 2003;) as cited by Chigona and Chigona (2010) it has been shown that a handful of teachers are effectively integrating ICTs in curriculum delivery even where there is availability of infrastructure.

Although ICT is believed to have positive benefits on mathematics education, but sometimes teachers do not use ICT at all or use it in a very traditional form, such as using it to sustain direct teaching (Ertmer, 2005; Goos and Bennison, 2008), as cited in Yang and Leung, 2015). ICTs which include radio and television, and also newer digital technologies like computers and the Internet have been considered as essential enabling tools for educational change and reform. Different ICTs when used correctly can help expand access to education, strengthen the relevance of education to the increasingly digital workplace, raise educational quality, for example, help to make teaching and learning into an engaging, active process connected to real life. It is still new in using computers and the internet in developing countries and there are faced with limited infrastructure and high costs of access to the computers and the internet (Tinio, 2003).

According to Broekman (2002), cited in Kaino and Salani, (2004), the students are in control of their own learning through the use of technologies. The students work independently, free to set their own goals, plan their activities and freely share their opinions with teachers by using modern approaches. The teacher acts as a guide and counsellor in the modern school of thought (Kochar, 1992). Using ICT has brought drastic progress in the education fraternity in developed and developing countries. It has also brought a revolution in the teaching-learning process by changing the roles of teachers and students. ICT is being used in developed countries while in developing countries like Pakistan; its use is limited due to cost and scarce resources. ICT is important for shaping the new global economy and producing quick changes in society. The new ICT tools have changed the ways the people used to communicate, resulting in a significant transformation in industry, agriculture, medicine, business, engineering, and other fields. Therefore, ICT can transform the nature of education, teaching methods, and the role of students and teachers in the learning process. Teacher's lack of ICT knowledge and skills is the stumbling block to implementing ICT and there is a need for further training of teachers in this field (Safdar, Yousuf, Parveen and Behlo, 2011).

The advent of computers in African primary and secondary schools is a new phenomenon (Khan et al., 2012), as cited in (Mndzebele, 2013a). A highly skilled and educated manpower with aptitudes and skills in the application of ICT is vital for Africa to compete in the global economic environment (Lawless and Pellegrino, 2007), as cited in (Mndzebele, 2013a). This calls for policies that promote broad access to skills and competencies, and especially the capability to be ICT literate (Swaziland Government Ministry of Education and Training (SMoET) in corporation with Japan International Corporation Agency (JICA), 2012), cited in (Mndzebele, 2013a). This can be achieved by providing broad-based formal education, creating incentives for teachers and individuals to go for continuous training (The Swaziland Education and Training Sector Policy, 2011), as cited in (Mndzebele, 2013). The government should partner with the private sector for resource mobilisation to fund the use of ICT in education (SMoET) in corporation with JICA, 2012, as cited in (Mndzebele, 2013).

The world is quickly changing into a global village. The country should nurture a computer culture in order to face its challenges (Safdar, et al, 2011). "There is a global trend in both educational policy and research to recognize the need to reform education from traditional paradigms of teaching and learning into more innovative forms of pedagogical practice. These areas of practice and change are often described as information or knowledge society, emerging pedagogy and 21st century skills. Teachers play an important part in redeveloping schools into modern, technology-enhanced educational institutions (Ottestad, 2010).

ICT is an integral part of the global world and its value in schools is to help in knowledge creation, knowledge sharing, problem solving, communication, group and cooperative learning, the development of economic and social change. According to Tedla (2012) new technologies promote and transform teaching and learning. He said that ICT also provides an effective teaching-learning atmosphere by providing opportunities for effective communication between teachers and students. Tay et al. (2012) also found out the use of drill and practice in mathematics allowed students to master basic computational and arithmetic skills and immediate feedback worked as a motivational source for more engagement in the learning activities (Mathipa and Mukhari, 2014).

The authors concur with other findings that in the present world we are living in, ICT is ubiquitous in all works of life and forms part of the youth's culture. Various ICTs are used for entertainment, social communication, searching, transmitting and sharing knowledge. Siemens computer and cell phone games help develop those needed skills like problem solving, which are required to be mastered by students. Therefore, when ICT is correctly used by enthusiastic and astute teachers, students of different learning styles and needs can be assisted to manage their learning and to master content at their own pace. Also, ICT is indispensable in teaching and learning because they provide access to information and provide learning outside the classroom. Castells (2010) adds that students should use new ICT to access knowledge to be powerful as knowledge is equated with power. For example, the students can use the internet as a point of reference and a means of communication with peers and experts. In undeveloped and developing countries, ICT offer unprecedented opportunities to promote and enhance educational systems

and reduce a sense of isolation and provide access to knowledge in ways unknown before (Mathipa and Mukhari, 2014).

According to researchers, ICT usage in education has the potential to create the self-programmable workplace force to compete with anyone, anywhere and at any time (Aktaruzmann et al., 2011; Castells, 2010 cited in Mathipa and Mukhari, 2014).Therefore, it is of importance for teachers to use ICT for them to teach digital children and attain new ways of teaching and learning suitable to the era powered by use of new technologies (Mathipa and Mukhari, 2014).

Furinas and Marinas (2006) cited in Myers (2009) affirm that computers are vital to everyone's life. The children need to learn computers to prepare them as tomorrow's adults. They further state that mathematics teachers help increase students' understanding of the concrete to abstract with the use of hands-on manipulative and the current geometry sketching software. Furinas and Marinas further stated that based on Piaget's research, students should feel the mathematics through hands-on manipulations, see the mathematics through dynamic geometry software and decide and conjectures seeing geometric shapes change before their eyes (Myers, 2009).Moses and Cobb(2001) as cited in Myers(2009)saw technology as the great equaliser. Their discussions on the teaching of algebra support the belief that technology assists in organising thoughts. They saw technology as an inevitable consequence of changing times (Myers, 2009).Technology is a comprehensive tool that can be used to springboard students from one level of conceptual understanding to the next. Choi-Koh (1999), as cited in Myers (2009) showed how technology, especially Geometer's Sketchpad (GSP), can move a student's learning of geometry from one level of understanding to the next in rapid succession (Myers, 2009).

Rojano (1996) argues that students can learn more mathematics in a deeper way with the correct use of technology. Technology provides students with ownership of the mathematics that is being taught by giving them ample time for modelling and conceptualising mathematical ideas (NCTM, 2000, as cited in Myers, 2009).They can generate various representations of solutions and quickly see the effects of changing the shape of an object with the use of technology. Students can see the changing of the perimeter, the area increasing or decreasing, and the volume

of a three-dimensional object becoming bigger or smaller. These changes occur in real time, providing instant feedback and students' freedom to solve their problems with no limitations of paper and pencil (NCTM, 2000; Myers, 2009), as cited in Myers, 2009).

The instructional technology is used in schools to enhance student learning. Constructivists are of the view that learners must construct their own understanding of whatever is being taught. According to this perspective, the teacher's task is neither of promoting knowledge transfer, nor of ensuring that students perform consistently according to a predetermined description of knowledge and skills. The teacher's role is to create an environment in which the students can make their own interpretations of knowledge while becoming ever more skilful in directing their own learning. Other constructivists recognised the computer as a potential ally and designed programs that took advantage of constructivist beliefs. The result has been computer-based programs that promote higher-level thinking and encourage collaborative learning (Williams et al., 2002).

The world's economies merely depend on scientific and technological advances, which have resulted in the knowledge's emergence-based economy. In all professions, a huge human capital is needed to uplift our socio-economic developmental agenda. Therefore, the teaching and learning of ICT to complement the collective effort of other subjects of study are required to achieve the knowledge-based economy. Hence, it is essential to develop a holistic ICT modality in subject areas to produce the requisite human capital by the 21st century's economies (Asinyo, 2009).

Students construct knowledge when given time to discover and practise skills in authentic situations for themselves. For example, giving students access to hands-on activities and letting them ample time and space to use materials that reinforce the lesson being studied, creates an opportunity for individual discovery and construction of knowledge to occur in this information age. The educational system is rapidly changing that ICT-based education is a necessity in all disciplines. The ICT-based education fosters curriculum development based on students' interest and promotes intrinsic motivation and stimulates the desire to learn. The world has a lot of information, making it a global village with the use of the Internet (Asinyo, 2009).

Technology use is changing the mathematics of statistics, graphing, geometry, matrices, and probability, to name just a few. Therefore, mathematics teachers are encouraged to make use of various educational technologies like graphing calculators, symbolic processing programmes, spread sheet and simulations to help their students to learn about such technology related topics (Heid, 2005; Rosen, 1999) as cited in Grandgenett, Harris, and Hofer, 2009). Many authors suggested the use of graphing calculators in high school mathematics classes as one of the best examples of the successful integration of technologies into teaching and learning (Fuson et al., 2005; Kaser et al., 1999; Reece, Dick, Dildine, Smith, Storaasli, Travers, Wotal and Zygas, 2005) as cited in Grandgenett, Harris, and Hofer, 2009). Innovative software programmes like Inspire or the Mathematica, or new technologies like robotics and global positioning systems (GPS) give interesting chances for mathematics learning. The students will become motivated producers of mathematical works instead of being passive consumers of prepared materials if they are actively involved in the study of mathematics (Grandgenett, Harris, and Hofer, 2009).

Asian, African and South American countries are mostly interested in educational technology, mostly in ICT, hoping their educational systems gain the pedagogical benefits associated with it. Drill and practice or tutorial software, for example, individualises instruction, gives immediate feedback to the students and can work at their own pace. Internet connectivity allows students to access remote sources of information and exposes them to different expert ideas and makes them aware that they are part of a global community. There is evidence that multimedia learning environments, simulations, and computer-based laboratory analysis tools foster higher mathematics, science, and language skills. Researchers show the ICT-infused classroom as highly interactive learning environments. Communication and collaboration between and among students, teachers, and outside experts take place through formal presentations, cooperative learning activities, and informal dialogue in large groups, small groups, or on a one-on-one basis. Some researchers believe that ICT promotes self-direction. Students learn to initiate their own learning through asking probing questions and searching for answers using different resources. Exposing students to technology creates tomorrow's employees who may be later expected to use ICT to increase productivity, reduce costs, and improve results (Rodrigo, 2003).

Computers have positive effects because of motivating students for learning (Reeves, 1998) as cited in Motshegwe, 2005). They are accepted by more teachers than other technologies and are generally widely supported by administrators, parents, politicians, and the public (Motshegwe, 2005). According to Reeves (1998), as cited in Motshegwe(2005) computer-based cognitive tools like databases, spread sheets and communication software have been intellectually developed to function as intellectual partners to allow and facilitate critical thinking and higher order learning. The students use these tools for analysing the world, assessing and interpreting information, organising their personal knowledge, and representing to others what they know (Motshegwe, 2005).

2.5 Teachers' role in using ICT

The effective use of ICT has a positive impact on teaching by changing teachers' role in the classroom. According to Jenkins (1999), as cited in Motshegwe (2005) ICT changes teaching and learning through its potential as a source of knowledge, a medium to transmit content, a means of interaction and dialogue. The role played by these technologies offers a challenge to teachers by making them change the way they have been doing things in the classroom. Teachers are now becoming facilitators of learning, organising teamwork and managing classroom activities. According to Maimela and Monyatsi (2016) teachers are agents of curriculum implementation who are important to the education system who can make or break the system. According to Assar (2015) teachers are critical change agents at education and they are the instruments by which changes will occur in education.

Jenkins highlights some teachers' role as a change in relationship with pupils, the role to facilitators and managers who support learning and, a change in the content and scope of teaching. Wheeler (2000) as cited in Motshegwe(2005) argues that it is no longer enough for teachers to just impart content knowledge. These technologies can do this part, and therefore it is vital for teachers to encourage critical thinking skills, promote information literacy and nurture collaborative working practices to prepare children for a new world. Teachers and students communicate with each other, learn flexibly, and globally collaborate with others through the Internet. Geographical distance is no longer a barrier, and the borderless provision of education to all can be achieved (THES, March 2000) as cited in Motshegwe, 2005).Shared teaching

approaches and resources can be through communication with other educators and may be integrated across the curriculum (Motshegwe, 2005).

It is the mandate of the Botswana government to equip all her citizens with ICT skills that they can apply in their lives. The Ministry of Education found it relevant to address ICT issues in the curriculum and to ensure we find these technologies in schools. The implementers of the curriculum are also equipped with the required skill to effectively implement these in school (Motshegwe, 2005). The ten-year basic education one of its goals is to prepare students for the world of work. ICT has increasingly become essential in every aspect of society, including work places. It expands our access to an understanding of the global village. It also let people in all spheres of life to benefit from computers as personal tools, to collaborate in groups and to communicate locally and globally (Learning and Teaching Scotland, 2000) as cited in Motshegwe, 2005).Students today in schools need ICT knowledge, skills, and awareness to be successful in their future endeavours. The future economy of our country will depend on a high level of ICT capability from its citizens to be technologically inclined and to compete internationally (Motshegwe, 2005).

Clements (2003) as cited in Myers (2009) argues that teachers must be ready for a big change when they teach with geometric software. He further stated that even teachers experienced with geometric software are uncomfortable with using this software in the beginning. These teachers stated that they were uncomfortable giving up both control of the classroom and the students (Myers, 2009). Teachers see their roles changing with the use of new technology (Pearson and Naylor, 2006) as cited in Motshegwe, 2005). The teachers who frequently use ICT seem to move from the paradigm in which they act as transmitters of knowledge to a paradigm whereby they act as co-constructers of knowledge Lee (2002, p.8) as cited in Motshegwe (2005) and perceive ICT as a catalyst in transforming their teaching (Dede, 2000) as cited in Motshegwe, 2005). In Mumtaz's study it is stressed that:

> "[teachers] perceive that their practices became more students centred […] the more extensively involved teachers were in professional activities, the more likely they were to have teaching philosophies compatible with constructivist learning theory" (2000, p.324). Therefore, ICT can be a catalyst in changing the teaching-learning process from being teacher-oriented to learner-oriented. Teachers extend their roles from worksheet designers to web designers (Dede, 2000), as cited in (Maholwana-Sotashe, 2007).

The correct use of technology is because of a move from teacher-centred approaches to a more flexible and student-centred atmosphere. A technology-rich learning environment comprises collaborative and investigative approaches to learning, increasing integration of content across the curriculum and highlighting on the concept of development and understanding. Teachers and students' roles change to co-learners with the use of technological tools Nkhwalume and Liu (2013). Eze and Adu (2013), affirm that integrating computers and some teachers accepted internet while others rejected the technologies. The Internet offers rich information, which is now impossible to track the amount of information presented (Eze and Adu, 2013).

Computer-assisted learning has been found to enhance the development of mathematical skills and the cultivation of a deeper conceptual thinking as compared to traditional mathematical teaching method. Studies have shown that the mathematical difficulties experienced by students later are because of insufficient development of mathematical thinking during their tender ages. Many studies' results link the correct usage of computers with the ability for students to more efficiently understand various mathematical notions. Many studies have associated a positive relation between the use of computers and the development of mathematical thinking in the school (Zaranis, 2014).

The 1990s, computer communications and information access, especially with the accessibility of internet-based services like electronic mail and the Worldwide Web (WWW) were established. CD-ROM replaced floppy disk and educators became more focused on the use of the technology to improve student learning as a rationale for investment (Noor-Ul-Amin, 2012).

2.6 Botswana context: ICT deployment in Botswana Education system

Botswana is one country that has heavily invested in education. Many of her secondary schools have purchased computer hardware and software and have provided professional development to teachers hoping they will use technology Kgokgwe (2012), this is under the (Revised National Policy on Education, 1994). Regular use of ICT to support teaching and learning depends on availability of equipment in the learning environment (Jimoyiannis et al. 2007). ICT equipment like computers, internet, telephone, digital camera, data projector and cell phones are found in Botswana secondary schools (Kgokgwe, 2012). Although various researchers agree on effectiveness of using ICT to support teaching and learning but teachers continue to feel ill-equipped to use technology to support learning even though of current availability of the in-service opportunities (Jimoyiannis et al., 2007), cited in (Kgalemang, 2015).

Botswana has attempted to provide computer resources for her junior secondary schools and this is evidenced by the fact that all junior and senior secondary schools have fully equipped computer laboratories(Isaacs, 2007).The main problem is that many schools even though they struggle to effectively use these resources and while computers are available in most schools but they are not connected to the internet thus preventing their use in internet-based instruction like access to online discussion forums and investigations (Sithole and Lumadi, 2012).

To improve the quality of education system in Botswana ICT was recommended as a driving force. Government has done significant efforts since 1993 to address these recommendations. The Principal Education Officer I in the IT Unit report of 2003 Kgokgwe (2003) shows that in 1996 a school computerization project was piloted on eleven Junior Secondary Schools and later on was rolled out to all Junior Secondary Schools in Botswana to be computerized. According to Kgokgwe (2003), the project was run in three phases from 1999 to 2002. The first Phase was in 1999 comprising twenty-five Junior Secondary Schools with each equipped with a computer laboratory and a computerisation package made up of 20 Desktop computers, Network Printer, Linux Network Server, 50 Surge Protection Plugs, 50 Security Cables, IKVA UPS, 10 KVA UPS and a Multi Media Projector (Garegae and Moalosi, 2011).

The second phase began in 2000 and comprised sixteen junior secondary schools with every school equipped with a laboratory and a computerisation package and funded jointly by Botswana and United States of America. Promotion of collaboration, exchange of information and ideas between students and teachers for these two countries was highly emphasised on this phase. The remaining 154 junior secondary schools of the last phase were rolled out in 2002 and their computerisation project received same equipment as those four other schools in the previous two phases. The Botswana Revised National Policy on Education (RNPE) of 1994 recommended the Computer Awareness Programme whereby every student should attain basic computer awareness course. The RNPE also recommended that computer awareness should be drawn and incorporated into Secondary Education programme (Garegae and Moalosi, 2011).

There was an introduction for the first and current computer awareness programme syllabus in 1997. The students graduating from schools were expected to attain ICT knowledge and skills relevant to various needs and challenges of the market job emphasising on self-employment and job creation. All teachers and students were to be computer literate in Senior Secondary Schools by the RNPE. Ever since then there was an introduction of computers in senior secondary schools by offering examinable computer studies subject. The schools are also expected to offer computer awareness to students who are not taking computer studies. The completion of the school computerisation led to 206 Junior Secondary Schools and 27 Senior Secondary Schools benefited from these. The ThutoNet ICT policy was established in 2006

whereby there was a connectivity of schools. [And that]… schools [should] have access to a computer, and to computer-based communications like the internet Republic of Botswana(1997:5).The belief was that youngsters would be globally competitive because of ICT. The ThutoNet was established for ICT integration and also schools to be used as centres or cafes for communities to benefit from (Garegae and Moalosi, 2011).

Every school has a minimum of about two computers to be used for typing tests and examinations and other managerial issues in the teachers' office beside 20 PCs. There was an introduction of a computer awareness programme in Junior and Senior Secondary Schools for students to be equipped with computer skills. Introducing this programme was because computers are commonly found in every aspect of human nature to be more productive. Most jobs require people who are computer literate. Botswana, to better compete globally like other countries, found it fit to increase the technological background of her people (Republic of Botswana, 1997). The University of Botswana embarked on Computer Studies programme for degree holders for the past six years to equip Senior Secondary Schools teachers with ICT skills. There was an introduction of non-programmable scientific calculators in 1996 at Junior Secondary Schools. The non-programmable scientific calculators were a long time used in Senior Secondary Schools at COSC (Garegae, 2012).

Although calculators were introduced in schools but the students seem not to have used them before in the teaching and learning of mathematics. The calculators were frequently used for tests and examinations purposes rather than exploring mathematical concepts and principles by students. The teachers kept calculators under locked cabinets for fear of students losing them outside lessons (Garegae -Garekwe, 1999). The schools have no guidelines policy on the use of calculators. The computers are not used in schools for subject integration (Garegae, 2012). It is the mandate of the Ministry of Education to ensure addresses ICT issues in the curriculum and to ensure these technologies are in schools and curriculum implementers are equipped with necessary skill to effectively implement these in schools (Motshegwe, 2005).

Botswana, through Connecting Communities initiative, made a big step in providing rural and urban people with internet networks for voice and data transmission. There are constraints that hinder realisation of the ICT subject integration in the teaching and learning of mathematics in schools. The practicing teachers were not equipped with skills when non-programmable calculators were introduced in the Junior Secondary Schools mathematics syllabus in 1996. This led to most of them not being ready to embrace calculators in their instructional practices. Although teachers have used calculators in their learning but they are unknowledgeable of how to use these gadgets in their teaching (Ballheim, 1999), as cited in (Garegae, 2012). They are in losing classroom control. Introducing ICT into the school curriculum should be based on competent and confident teachers because it's correct implementation only depends on their competence (Garegae, 2012). The teachers are the enablers of deployment of technology to assist the learning process (Eristi, Kurt and Dindar, 2012 cited in Soetab and Coker, 2018).

Introducing computer awareness and computer studies in Junior and Senior Secondary Schools respectively and the establishment of the country's ICT document, Maitlamo show government's commitment to raise the national ICT skills towards an information society as uplift the national ICT skills towards an information society as stipulated in (Botswana's Vision, 2016). There is no clear definition of the role of ICTs as the teaching/learning tools across the curriculum, even though there are aims in embracing ICT. According to Lajoie (1993), as cited in Nkhwalume and Liu (2013), the use of technological tools is to support cognitive processes by reducing the memory load of the student and encouragement of problem-solving process. Also, ICT tools share cognitive load by minimising the students' time spent on computation and letting them to engage in mathematics that would be inaccessible and stretching their opportunities. Such tools promote logical reasoning and hypothesis testing by allowing students to easily test conjectures (Nkhwalume and Liu, 2013).

Only computer awareness teachers are accessible to computer laboratories despite Botswana secondary schools been furnished with computer laboratories and computers. The non-computer awareness teachers and students are denied access to computer laboratories and computers, which leads to underutilisation of ICT gadgets in mathematics teaching in the schools. The computer awareness course has a negative impact on its implementation in the schools because of being not examinable. The IT officer at the Ministry of education and Skill Development said some School Heads excluded computer awareness in their school timetables because they felt it was unimportant and time consuming if included. The computer awareness lessons are not taken seriously but most students in urban areas are knowledgeable with the computer basics(Garegae, 2012).Most ICT programs in mathematics education have been administered and fruitful because students take control of their own learning (Broekman et al, 2002). ICT provides motivation and variety, generates enthusiasm, interest and involvement, maintains attention and enjoyment, and enhances thinking and problem-solving skills (Sibiya 2003), as cited in (Chakalisa et al., 2010).

2.7 Conclusion

In conclusion, it is clear from the recent literatures that ICT has the potential to revolutionise the quality of mathematics teaching and learning when deployed where applicable and appropriate, with its deployment done effectively and efficiently under proper considerations. With that said, the teachers' role in ICT deployment is critical hence it is also important for teachers to have the relevant skills in using ICT. Thus, the relevant authorities should ensure teachers are equipped with skills that allow them to use proper contemporary pedagogical approaches that deploy ICT in their teaching.

Chapter 3

Research Methodology

3.0 Introduction

This chapter presents the research methods and procedures to be employed in determining the use of ICT in Mathematics teaching and learning. Thus, it describes the research design, population, sampling procedures, data collection procedures, ethical consideration and issues of validity and reliability. The researcher set the procedures such that they would by all means reduce contamination of results, bias, ambiguity as well as safeguard the reputation and privacy of the respondents.

3.1 Research Paradigm and Design

The word paradigm comes from the Greek word *"paradeigma"* which means patterns. Kuhn first used this word in research in 1962. In his view, a research paradigm refers to 'the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed.' Other scholars see the research paradigm as an approach or a research model of conducting research that has been verified by the research community for a long time and has been in practice for hundreds of years. Hence, it is therefore in this essence that most scholars refer to a paradigm as the worldview or a set of assumptions about how things work.

There are several research paradigms that can be employed in research work which include the positivist, constructivist, pragmatist, and interpretivist, just to mention a few. According to Guba (1990) cited Sale (2002) research paradigms can be characterised through their ontology (what is reality), epistemology (how do you know something) and methodology (how do you go about finding it out). This study will use the constructivist paradigm shift. Constructivists are of the view that there is no single reality or truth and therefore reality needs to be interpreted. Hence, understating and addressing problems depends on the multiple understanding of problems by the various people working around them.

Since this study is more into eliciting teacher experiences, and the means and ways ICT is integrated in the mathematics teaching and learning as well as the challenges that come about with that, the constructivist paradigm shift is the most suitable framework that can be used because it deals with issues of knowledge construction. Constructivists are of the view that knowledge is built or constructed through experience as opposed to being discovered hence it is suitable for this study which is more concerned about teacher experience acquired through observing and experiencing the world of mathematics and ICT. There are various definitions and interpretations for the term research design. It can be described as the arrangement of conditions for data collection and analysis in a manner aiming to combine relevance to the purpose with the economy of procedures (Anderson, 2003). Research design is also portrayed to be a set of methods and procedures used in collecting and analysing measures of the variables specified in the research study. According to Saunders, Lewis and Thornhill(2012), research design can be described as a general plan about what you do to answer the research question.

According to Trochim and Kane (2005), research design 'provides the glue that holds the research project together. A design is used to show how all the major parts of the research project work together to address the central research question.' The research design's importance is emphasised by Burns and Grove (2001) who stated that the purpose of a research design is to achieve greater control of the study and to improve the validity of the study by examining the research problem. A couple of factors influence the decision of the research design like time dimensions, focus of the study and also the analysis units. Therefore, this study will utilise a qualitative method approach aiming at understanding and interpreting the outcomes of ICT deployment in the teaching and learning of mathematics at Junior Secondary Schools in the Mahalapye Region.

The qualitative approach is most suitable for this study because the study is concerned with human behaviour, which cannot be quantified. It deals with human experience and it is based on the analysis of words rather than numbers. The qualitative research method seeks to explore rich information usually collected from fairly small samples and includes methods like in-depth interviews, focus groups, action research and ethnographic studies (Mathers et al., 2009). Qualitative research is a well-rounded approach involving discovery. It is an effective model occurring in a natural setting which allows the researcher to develop a level of detail from being highly involved in the actual experiences (Creswell, 2003) in (Williams, 2007). Qualitative researchers often take a naturalistic approach to the world (that is, studying things in their natural setting), while trying to understand phenomena through the "voice" of the participants (Edmonds and Kennedy, 2013).

Qualitative research is conducted in natural settings. This means qualitative researchers study things as they are without manipulating the environment. For instance, there are no experimental and control groups and data collection is done in the field but not in a laboratory. Ordinary events and behaviours are studied in their everyday context. This process generally involves interacting with people by interviewing them and observing the setting. People are not taken away from their own settings but instead the qualitative researchers go to the people, allowing for gathering of sensory data: what is seen, felt, heard Rather than removing people from their settings, qualitative researchers go to the people, allowing for the gathering of sensory data: what is seen, felt, heard, and even tasted or smelled (Given, 2008).

Qualitative researchers collect data on the field at the place where respondents experience the issue or problem under study. They neither bring individuals into a lab nor do they normally send out instruments for individuals to complete. This up-close information collected by directly talking to people and seeing them and acting within their context is the main characteristic of qualitative research. The researchers have face-to-face interactions in the natural setting often over time (Creswell, 2014). According to Willig (2013), qualitative researchers study people in their own territory, within naturally occurring settings (such as the home, schools, hospitals, and the street).

Although there are various methods to use in conducting a qualitative research study, Leedy and Ormrod (2001) recommend case studies, grounded theory, ethnography, content analysis and phenomenological. This study intend to use a content analysis approach where data collection tools will be in- depth interviews and questionnaires as the main sources of data while classroom observation is to be supplementary.

3.2 Setting of the Study

The researcher shall conduct the study in and around Mahalapye, one of the large villages in the central region of Botswana, with five junior secondary schools: School E, School F, School G, School H, School I.

3.3 Population, Sample and Sampling Procedures

The term population refers to a group of individuals with at least one common characteristic that differentiates them from the rest of other groups (Best and Kahn, 2006). The population of this study shall comprise government junior secondary school mathematics teachers in the Mahalapye region. This population was chosen because of its suitability for this study, as the schools are mandated to pilot the use of technology in mathematics teaching and learning. Teachers are the implementers of the mathematics curriculum and therefore, are likely to encounter challenges and everything related to the integration of ICT in Mathematics instruction. Hence, this is in agreement with Spradley (1985), who states that when choosing the study population, one should remember its involvement in the problem under study. Thus, they are in a better position to provide useful information based on their experience.

From a study population, one needs a sample for the study. Seaberg (1988) defined a sample as a small portion of the total set of objects, events or persons, which together comprise the subject of our study (p. 240) while Wiersma and Jurs (2009) define a sample as "a subset of the population which the researcher intends to generalise the result" (p. 325). Therefore, a sample can be regarded as an element of the population that shall be considered for the actual inclusion in the study because it can give a possible accurate conclusion for the study. The purposive sampling technique is the most widely used sampling method in qualitative research in which the researcher chooses subjects who are knowledgeable on the issue being addressed in

the research (Oppong, 2013). According to Etikan, Musa, and Alkassim (2016) the purposive sampling technique is the deliberate choice of a participant due to the qualities the participant possesses. The researcher decides what needs to be known and sets out to find people who can and are willing to provide the information by virtue of knowledge or experience. According to Sharma (2017), purposive sampling, also known as judgmental, selective or subjective sampling, shows sampling techniques that depend on the judgment of the researcher when choosing the units (e.g. people, case/organisations, events, pieces of data) under study.

According to Given (2008), in qualitative research, purposive sampling is one of the common types of non-probability sampling whereby researchers use their judgment to choose a sample. In contrast to probability sampling in which each participant has same chance of being chosen, in non-probability sampling technique are chosen because they meet pre-established criteria.

Five mathematics teachers out of ten teachers will be purposively sampled for the research interview, with one teacher drawn from each of the participating schools, while the rest of remaining mathematics teachers will be used as questionnaire respondents on the use of ICT in mathematics teaching and learning process. The participants will be recruited by asking them to leave their email addresses and phone numbers and the researcher will contact them to take part.

3.4 Data Collection Instruments and Methods

The major focus of this study is ICT deployment in mathematics teaching. It can be considered a study of a social phenomenon with teachers mandated to see to it that ICT is integrated into the teaching and learning of mathematics. Therefore, a qualitative inquiry approach gathered information from the teacher respondents. A qualitative inquiry approach looks for verbal accounts or descriptions in words, or it puts observations into words (occasionally it also uses other forms of description). The qualitative inquiry has various methods for obtaining information with qualitative interviews being the most commonly used approach, following semi-structured and/or unstructured interview formats. Participants in these forms of interview are asked to provide elaborated accounts about particular experiences. Good

practice is to develop an interview guide that helps the interviewer focus the interview without imposing too much structure. Hill et al., (1997) recommend providing interviewees with a list of questions before the interview as cited by (Elliott and Timulak, 2005).

Large amount of data can be produced using qualitative research. This may include verbatim notes or transcribed recordings of interviews or focus groups, jotted notes and more detailed "field notes" of observational research, a diary or sequential account, and the researcher's reflective notes made during the research. Transcripts and notes are raw research's raw data which provide descriptive record but they are unable to provide explanations. Therefore, the researcher has to make sense of the data by sifting and interpreting them (Pope, Ziebland and Mays, 2000).

Since this study is concerned with a social phenomenon about teacher experiences on integrating ICT in mathematics teaching and learning, the use of interviews, questionnaires and observations will give a true reflection of the issue under investigation. Thus, the researcher will utilise the interview and questionnaire to gather data for this project with each instrument carefully chosen to maximise the amount of relevant data collected within a limited time frame. Direct or participant observations, interviews, archival records or documents, physical artefacts, and audio-visual materials will extensively draw a more accurate portrayal of the realities of the issue under study.

The researcher intends to spend time with the people under study on the site to collect data and take field notes. The data collected from interviews will be documented as teachers share their views concerning incorporating ICT in the teaching and learning process.

3.4.1 Interview

The interview method takes the form of a dialogue whereby the researcher seeks to elicit information from the participants about how they think. Interview questions can be structured, semi-structured or open-ended depending on the purpose of the interview. One of the advantages of using the interview is that it is flexible (Drew et al., 2008). So interviews have the potential to provide greater depth of information (Sharma, 2010).

There are many types of interviews that can be used to gather information. According to Fontana and Frey (2000, p. 645), cited in Newman and Benz (1998) interviewing is one of the most common and powerful ways in which we try to understand our fellow human beings. Interview protocol is one of popular qualitative research design. Participants may give in-depth information pertaining to their experiences and viewpoints of a certain topic in interviewing. At times interviews are used with other types of data collection in order to give the researcher well-rounded collections of information for analyses (Daniel and Turner, 2010).

Interview is useful for collecting in-depth information. In an interview situation, it is possible for an investigator to get in-depth information by probing. Interviewing is the preferred method of data collection in situations where in-depth information is needed. Information can be supplemented. An interviewer can supplement information obtained from responses with that gained from observation of non-verbal reactions. Questions can be explained. It is less likely that a question will be misunderstood as the interviewer can either repeat a question or put it in a form the respondent understands (Kumar, 2011)

This study will use a semi-structured interview to gather qualitative data. It is the most suitable as it seeks to get an in-depth understanding of the problem under investigation. Thus, the semi-structured interview intends to follow a pre-determined sequence of questions related to the research questions which is expected to give the researcher greater flexibility. The researcher purposes to prepare some field notes from the interviews, make follow-up interviews, observations and casual encounters with participants as and when necessary.

It is of importance to begin the purposeful sampling to determine what selection criteria will be chosen in choosing the participants. For this study, when choosing the participants for the interviews the following selection criteria will apply. This is the crucial criteria as the aim of the study will be to investigate 1. What are the levels of deployment of ICTs in teaching and learning mathematics at the junior secondary level in the Mahalapye region? Participants will be mathematics teachers. This is an important criteria as the aim of the study will be to investigate levels of ICTs integration in mathematics teaching and learning. The interview sample will comprised of five mathematics teachers.

2. How do junior secondary school mathematics teachers in the Mahalapye region deploy ICT media in their teaching?

Thus, data will be gathered using a direct verbal interaction between the researcher and the respondents. This interaction will allow participants to open up and give the interviewer a chance to breakdown questions to them, thus allowing a relaxed environment to obtain comprehensive data. The researcher gathered the data in qualitative research more in a verbal and visual rather than in a numeric form (Devetak et al., 2010). Rubin and Rubin (2005) describe qualitative interviews as conversations where the researcher gently guides the interviewee through an extended discussion. Each interview is unique and often over one interview is conducted with the same interviewee. The interviews will be far less structured than the interviews associated with quantitative research since the researcher desires to get rich, detailed answers; (Torkar, Zimmermann, and Willebrand, 2011). Brown and Dowling (1998) explain that interviews enable the researcher to explore issues in more detail and give opportunities for probing and prompting questions.

Interviewing gives the researcher more flexibility and personal control, unlike using a questionnaire. For example, a respondent who finds the phrasing of an interview question unclear can ask for the interviewer to explain the question. Interviewees can more easily elaborate on their answers than can respondents who complete questionnaires. The one-on-one personal relationship that an interview provides is usually more effective in eliciting respondents' sincere participation in a research project than is the impersonal relationship implied by questionnaires that are distributed to a group or sent through mail. Interviews are more efficient for collecting information about people's knowledge, personal backgrounds and opinions as compared to direct observation (Thomas, 2003).

An interview plays a crucial role in the lives of many people. The purpose of an interview is to find out what is on someone's mind. People are interviewed to find out from them those things we cannot directly observe (Patton, 1980, p.196 cited in Greenfield, 1996). The interview is the most common method used by researchers to inform them about social life. Interviewing could thus be regarded as the universal mode of systematic enquiry (Holstein and Gubrium, 1995, p.1).

"An interview involves an interviewer reading questions to respondents and recording their answers" (Monette et al., 1986, p.156). To Burns (1997, p. 329), "an interview is a verbal interchange, often face to face, though the telephone may be used, in which an interviewer tries to elicit information, beliefs or opinions from another person.

Both of the research questions in this study are central to the research interview. Research Q1: What are the levels of deployment of ICTs in teaching and learning mathematics at the Junior Secondary phase in the Mahalapye region? Research Q2: How do junior secondary school mathematics teachers in the Mahalapye region deploy ICT media in their teaching? The researcher elaborates more on Appendix A.

3.4.2 Questionnaire

A questionnaire can be used to cover a large population. Therefore, it will be used in this study to supplement the interview and observation. According to Verma and Mallick (1999), a questionnaire that is well-constructed is cheap to use to collect data. The questionnaires will be self- completed by the respondents.

This study will use an open-ended format questionnaire. In situations where sensitive questions are asked it helps to increase the likelihood of getting accurate information.Open-ended questions allow the participants to answer the question in their own words (Kumar, 2011).

3.4.3 Observation

Observations assist the researcher to identify and guide relationships with informants, to learn how people in the setting interact and how things are organized and prioritized in that setting, to learn what is important to the people in the social setting under study, to become known to participants (Schensul, Schensul, and LeCompte, 1999).

The researcher have time to record in the form of field notes what he or she have learned which can later be used to recall what was observed in the research setting. Through observations, you may learn about activities that participants may have difficulty talking about in interviews, because the topics may be considered impolite or insensitive for participants to discuss (Marshall and Rossman, 1995).

In most instances, it is important to hide the identities of participants; this allows you to obtain sensitive information and puts informants more at ease about being observed. You are more likely to find that participants, when confidentiality is maintained, are more likely to share their deepest feelings Kawulich (2012). According to Kumar (2011) in qualitative studies observation is being used as a technique for gathering information about a social interaction or a phenomenon.

Participant observation and non-participant observation are types of observation. Non-participant occurs when a researcher is not involved in the group but remain passive observer, watching and listening to its activities and conclusions drawn from this. non-involved in the group but remain passive observer, According to (Bryman, 2008; Cohen et al., 2011) cited in Sharma (2013) a non-participant observation technique involves the researcher sitting or standing on the side while social activities like teaching and learning are taking place, both inside and outside the classrooms (Bryman, 2008; Cohen et al., 2011).

According to (Whisker, 2001) observation can be a rich source of information for the researcher because it enables him/her to capture what people actually do instead of what they say they do. The researcher can observe them in context and relate to his or her research questions while observing. Observational data are eye-catching because the researcher can gather 'live' data from 'live' situations and he/she is given time to look at what is taking place in a situation rather than second hand (Patton, 1990).This allows researchers to comprehend the context of programmes, to be open-ended and inductive, to see things that might otherwise be unconsciously missed, to discover things that participants might not freely talk about in interview situations, to move beyond perception-based data (e.g. opinions in interviews), and to access personal knowledge. Since observed incidents are less predictable, there is certain freshness to this form of data collection that is denied in other forms, e.g. a questionnaire or a test (Cohen, Manion and Morrison, 2000, p. 305, as cited in Newman and Benz, 1998).

The researcher in this study will use an observation because it will suit the nature of the study, as it was already mentioned that this study will be done in a natural setting which is the school. The researcher had planned to observe the teaching and learning of mathematics inside the classroom to see if ICT was deployed in teaching and learning. The researcher will also observe the classroom setting to see if there was any factor that might affect the process of ICT integration in the mathematics teaching and learning process. The researcher used naturalistic observation to gather information to supplement data that have been collected through interview and questionnaires (Marshal and Rossman, 2011). According to LaFrance (2016) field notes are written as soon as possible after the observation or interview.

For content analysis' sake, during observations, the teachers' official documents will be randomly selected. Ten schemes of work, ten lesson plans, ten teaching notes and ten students' exercise per school will be looked into, to find out if teachers are using ICTs in their teaching and learning of mathematics. Examining these documents will give the researcher a clear picture of teachers' teaching practices.

3.5 Validity and Reliability of Instruments

To confirm the validity of the instrument, the developed interview guide and observation guide will be face-validated by three colleagues who will be non-participants. After the initial validation of the interview guide and observation guide, a pilot study of these instruments will be carried out to ten participants who will be purposively sampled based on that they are mathematics teachers. They will not be part of the main study. This will be tested on participants in two of the secondary schools outside Mahalapye based on the two research questions for study. According to Tachie and Chireshe, (2013) a pilot study was undertaken for relevance checking carried for checking on the relevance and usability of the instrument prior to the main study. The pilot study will assist the researcher to check for flaws, limitations, or other weaknesses, to make some corrections before the implementation of the main study (Kvale, 2007). A pilot test should be conducted with participants that have similar interests as those that will participate in the implemented study. The pilot test will also help the researchers with the refinement of research questions (Daniel and Turner, 2010).

3.6 Data collection procedure

According to Strauss and Myburgh (1996) data collection is a process whereby the researcher interacts with the respondents to obtain data from them. Nxumalo (2001) asserts that the focus of the interaction should be to maximise validity and minimise inconvenience to the respondent before, during and after the process. It is therefore the responsibility of the researcher to balance the research and the respondents' convenience. The researcher will sought permission from the Ministry of Education and Skills Development and the Regional Education Office to collect data from teachers. Since the study will be on ICT deployment on the mathematics teaching and learning process, qualitative data will be required for this study. Therefore, interviews will be used to obtain an adequate amount of information on what was happening on the ground with the questionnaire and observation data that will be used to substantiate data collected through interviews.

3.6.1 Data Collection procedure for Interviews

Five mathematics teachers will be purposively interviewed. Interview schedule will be The interview process will be explained explicitly to the interviewees prior to the commencement of the interviews. Consent forms will then be completed before the interview process by each interviewee. All the interviews will be planned for between 30-45 minutes for each participant and will be conducted during the school hours and in the school premises during each teacher's free time.

The interviews will be tape recorded and transcribed verbatim. This will involve listening to the interview tapes; transcribing the interview sessions. It will also involve reading the transcripts several times; summarising the transcripts and choosing categories; coding statements; linking themes; selecting quotations; and ultimately, generating theory grounded in the data and writing it up coherently (Basit, 2003).The researcher will examine the transcripts from the interviews to determine the main categories to use to code data. Rich data will be coded manually. The idea was to ascertain 'what' they feel and 'why' they feel that way. This also incorporated 'who' felt the way they did, and 'where', 'when' and 'how'. Such a detailed scrutiny could not be carried out by using numbers, percentages and statistics. This applies to all qualitative data, whether they are analysed manually.

3.6.2 Data collection procedure for Questionnaire

An open-ended questionnaire will be used for the study. The respondents will be asked about their conception of the use of ICT in their teaching mathematics. The questionnaire (see appendix B) will comprise of three sections. Section A will be teachers' demographic information while section B and section C will be fifteen items of open-ended questions on teachers' conception about the use of ICT in their teaching and learning of mathematics.

A written list of questions comprises the questionnaire. The respondents will record the answers. In a questionnaire respondents will read the questions, interpret what is expected and then will write the answers. The only difference between an interview schedule and a questionnaire is that in an interview schedule it is the interviewer who asks the questions (and if necessary, explains them) and records the respondent's replies on an interview schedule while in a questionnaire replies are recorded by the respondents themselves. There is no one to explain the meaning of questions to respondents in a questionnaire. Therefore, it is important that the questions are clear and easy to understand (Kumar, 2011).

3.6.2.1 Ways of administering a questionnaire

· A questionnaire can be administered through mail, or self-administered. Therefore, the questionnaire will be self-administered by the respondents. The researcher will ask participants to self-administer after issuing the questionnaires to complete. The advantage of self - administered questionnaires is that there is a very high response rate as few people might refuse to participate in the study. Also, the researcher has personal contact with the study population and can explain the purpose, relevance and importance of the study. The researcher can clarify any questions that the respondents may have. It is the quickest way of collecting data and saves money on postage. If the study is about issues that respondents may feel reluctant to discuss with an investigator, a questionnaire may be the better choice as it ensures anonymity (Kumar, 2011).

3.6.3 Data collection procedure for Observation

The researcher will observe one lesson per mathematics teacher for forty minutes in each school while teaching to find out if they indeed use ICTs in teaching and learning of mathematics. Video recording will be used by the researcher but permission will be sought prior to recording. Soon after lesson observation the researcher will schedule time to go over the video tape and be familiar to it by replaying it repeatedly to familiarise myself with the data I had collected. I will then transcribe the recordings in verbatim over and over. In addition detailed notes will be taken after lesson observations as back up and informal conversations with the teachers.

An observation is one way to collect primary data in research. An observation is a purposeful, systematic, and selective way of watching and listening to an interaction or phenomenon as it takes place. There are many situations in which an observation is the most suitable method of data collection. For example, when you want to learn about the interaction of a group. It is also relevant in situations where full and / or accurate information cannot be elicited by questioning, because respondents either are not cooperative or are unaware of the answers because it is difficult for them to detach themselves from the interaction. When the researcher is more interested in the behaviour than in the perceptions of individuals, or when subjects are so involved in the interaction that they cannot provide objective information about it, observation is the best approach to collect the required information (Kumar, (2011).

3.6.3.1 Recording observations

Observations can be recorded in many forms. The researcher will videotape the activities. The advantage of recording an interaction in this way is that the observer can see it many times before interpreting an interaction or drawing any conclusions from it and can also have other professionals invited to view the interaction to arrive at more objective conclusions. However, one of the disadvantages is that some people may feel uncomfortable or may behave differently before a camera. Therefore, the interaction may not be a true reflection of the situation (Kumar, 2011). Before videotaping the sessions the researcher will sought permission from respondents.

3.7 Data analysis procedure

Smith (1997, p. 177) depicts data analysis as "categorization and ordering of information in such a way that sense is made of it and a final report that is true and accurate in terms of the study's subject is made," whereas Brink (1999) as cited by Tsanwani (2009) stated that the aim of data analysis is to reduce and synthesise information and to allow an inference about a population, while the aim of interpretation is to combine the results of data analysis with value statements, criteria and standards to produce conclusions, judgments and recommendations.

Throughout analysis, researchers try to gain a deeper understanding of what they have studied and to continually refine their interpretations. Researchers draw on their firsthand experience with settings, informants or documents to interpret their data (Taylor and Bogdan, 1998, cited in Basit, 2003). The qualitative data is being analysed to determine the categories, relationships and assumptions informing the respondents' general view of the world and of the topic stated (McCracken, 1988, cited in Basit, 2003).

Raw data can be pleasant for the eye but they do not the reader to understand the social world under scrutiny, and the way the participants view it, unless such data have been systematically analysed to illuminate an existent situation. Coding or categorising the data has an important role in analysis. It involves subdividing the data and assigning categories (Dey, 1993). Codes or categories are tags or labels for allocating units of meaning to the descriptive or inferential information compiled during a study. Codes usually are attached to chunks of varying-sized words, phrases, sentences or whole paragraphs, connected or unconnected to a specific setting (Basit, 2003).

Qualitative data are textual, non-numerical and unstructured. Coding is of importance vital for the plays a vital role in the analyses of such data to organize and make sense of them. What coding does, above all, is to allow the researcher to communicate and connect with the data to facilitate the comprehension of the emerging phenomena and to generate theory grounded in the data (Basit, 2003).

The qualitative data from both the observations and interviews will be analysed using thematic analysis. Thematic analysis is a method of systematically identifying, organising and offering insight into, patterns of meaning (themes) across a dataset. Through focusing on meaning across a dataset, thematic analysis allows the researcher to see and make sense of collective or shared meanings and experiences.

There are various forms to analyse qualitative data. The researcher can either use a thematic, descriptive approach or more in-depth methods (Bricki and Green, 2002). Therefore I will use thematic analysis.

A thematic analysis is one that looks across all the data to identify the common issues that recur and to identify the main themes that summarises all the views you have collected. Transcription of interviews and observations will be done and thematic analysis will be undertaken. Coding of all data prior to identifying and reviewing six main themes of familiarisation, coding, generating themes, reviewing themes, defining and naming themes and writing up (McCombes, 2020).

The researcher will look for a very quiet place and then replay audio recordings and watch video recordings to become familiar with them. Then transcribe those audio-visuals devices. The researcher will go through these transcripts of each interview and observation to code them. This will be followed by looking for patterns in those codes and come up with themes (Braun and Clarke, 2012).

The qualitative data from both the observations and interviews were analysed using content analysis which involved coding, sorting, reducing and editing data so it could be in the form that could be processed. Content analysis can also be referred to as categorising and indexing. These data were analysed using thematic content analysis approaches which called for the researcher to find the common patterns across the data sets, code/ label the data and finally create a coherent narrative write up.

The Interview (see Appendix A) and the Questionnaire (see Appendix B)

Both the Interview and Questionnaire seek to address the two research questions:

Research Question 1: What are the levels of deployment of ICTs in the teaching and learning of mathematics at the junior secondary phase in the Mahalapye region?

Research Question 2: How do Junior Secondary School mathematics teachers in the Mahalapye region deploy ICT media in their teaching?

The questionnaire will comprise of fifteen statements on styleThe data will be assigned numerical codes and categories. Once the data is entered onto the computer software, the researcher will check errors on the data. Once satisfied that the data entered into the computer is

correct, it will be analysed using descriptive statistics (basically using frequency tables and bar charts). This therefore means that the data collected would be coded and grouped under some themes to ease analysis. The themes are categorised as follows:

Theme 1: Teacher profile; This was concerned with obtaining the demographic information of the teacher respondents, their teaching qualification and their teaching experience in terms of years of teaching.

Theme 2: Teacher background on ICT knowledge (training acquired on ICT); this theme shall focus on finding out if teachers have any kind of training pertaining to using ICT in the teaching and learning of mathematics.

Theme 3: Common ICT media deployed; this theme seeks to find out the ICT media that are commonly used in the teaching and learning of mathematics and where they are deployed (in terms of mathematical topics).

Theme 4: Teacher conceptions of ICT; this theme deals with gathering information on how teachers view ICT.

Theme 5: Levels of ICT use in teaching; this theme is more concerned with finding out if teachers use ICT media in their teaching and how often they use it.

Theme 6: Teachers' achievements on using ICT in the teaching and learning process; this theme helps the researcher to gather information on finding out whether the participants have had any achievements regarding using ICT in the teaching and learning of mathematics.

Theme 7: Teachers' challenges on using ICT in the teaching and learning process; this theme is aimed at gathering information about the challenges that the participants encounter while teaching mathematics using ICT.

Theme 8: Teacher training on ICT; this theme is more concerned with finding out if teachers have the necessary skills that enable them to use ICT tools in their teaching.

Theme 9: Possible Solutions to ICT deployment in mathematics education; this theme seeks to find out from the respondents possible solutions to challenges of deploying ICT in the teaching and learning of mathematics at the junior secondary level

Appendix C: Classroom observation (Non-participant observation)

The researcher will observe five teachers with one teacher per school delivering instruction in one lesson to get to understand what happens on the ground regarding ICT deployment in mathematics teaching and learning at junior secondary schools in the Mahalapye region. Video recording will be used during those sessions and later. The observation will follow the themes that will be used for interviews and questionnaires but with a general look at the action taking place at classroom level.

3.8 Ethical Considerations

Before the proposed data is collected, the researcher intends to write official letters to get a research permit and research authorisation letters from the Ministry of Basic Education and Skills Development. The researcher will write a consent letter to all School Heads in the region inviting teachers to participate in the study. The letter will describe the entire study by stating the purpose of the study and explaining explicitly who will be responsible for which particular area of the project. The researcher will assure confidentiality regarding all information that will be collected, through guaranteed participants' anonymity by assigning identification numbers to respondents in lieu of names. The letters will be hand delivered to the schools for the participants to read those letters in the researcher's presence and be able to seek clarity immediately.

Analysing qualitative data is not a simple or quick task. If done properly, it is a systematic, rigorous and therefore labour-intensive and time-consuming exercise (Pope, Ziebland, and Mays, 2000). To analyse this study's data, descriptive statistics will be used. Interview data will be audio taped and transcribed using the data reduction technique (Miles and Huberman, 1994).

3.9 Constraints

The study's constraints will be time because it will be toward the end of the year and schools will have a tight schedule of examinations. The main shortcoming to this study will be limited to only five schools in one region that will provide the information to answer the research questions that will be raised in the study. Financial constraints during data collection will also be a possible problem with this study because the schools are far apart. The time factor will be a hindrance, as the research will be done within a specified period. Another limiting factor may be failure to fill the questionnaires by participants as they may agree or disagree to take part in the study. It will also be possible that the researcher's schedule might clash with the schools' action plans, which may cause some schools unable to respond at all. I had decided the population to be only mathematics teachers and exclude students because the researcher feels the teachers are the main people to use or not use ICT in the teaching and learning of mathematics.

The researcher will use a non-probability sampling method because it is easy and inexpensive to access. But it has a higher risk of sampling bias and cannot be used to make statistical inferences about the whole population. Each member has no equal chance of being selected in the population. The researcher chose non probability sample because it is suitable for a small population. I will use purposive sampling because it is a type of non-probability sample whereby the researcher uses his or her own judgment to choose a sample that is most suitable for the study. The purposive sample is always used in qualitative research whereby the researcher wants to gain in-depth knowledge based on specific concept rather than inferences on statistics.

3.10 Summary of the chapter

Qualitative researchers frequently take a naturalistic approach to the world; studying things in their natural setting. Observation, interview and questionnaires are often used in qualitative studies. In observation, the researcher can gather 'live data from 'live' situations. An interview method is whereby we interview people to find out from them those things we cannot directly observe. The questionnaire is also used because it is impossible to interview all teachers in schools. The questionnaire in this study will be used to supplement the interview and observation.

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APPENDIX A

INTERVIEW QUESTIONS

Theme 1: Teacher Profile

1. School Name; _____ 2. Gender; _____

Theme 2a: Teacher's Background information on ICT knowledge

2. Do you have any technology training? ☐ Yes ☐ No

If the answer is yes, the training was for how long? _____

If the answer is No, are you interested to go for training in ICT? _____

Theme 2b: Teacher's conception of ICT.

Why do you think/do the way you think/do with those ICTs you engage with in the teaching and learning of mathematics?

_____

_____

_____

Theme 3: Teachers Achievements on Using ICT in the teaching and Learning Process.

5. What are your achievements of using ICT in instructional practices?

_____

_____

_____

Theme 4: Teacher's Challenges on using ICT in teaching and learning process.

6. What are your challenges of using ICT in instructional practices?

_____

_____

_____

APPENDIX B

QUESTIONNAIRE

This questionnaire is part of a research study conducted to investigate the deployment of ICT in mathematics teaching in Junior Secondary Schools in Mahalapye Region. Please, respond to all items in the questionnaire.

Please note that, your responses will not be used in any way that will implicate you and the information that you shall provide will be used only for the purpose of the study and that respondents will remain anonymous.

Please read each question carefully and try to be accurate; remember there is no right or wrong answer.

Please complete the questions in full.

Pleas tick (√) the appropriate box

SECTION A

Demographic information

1. School Name: _____

2. Gender: Male ☐ Female ☐

SECTION B

1. What ICTs do you use in teaching and learning of mathematics?

_____

_____

_____

2. For what purpose do you use each of these ICTs for?

_____

_____

_____

3. How often do you use each of these ICTs?

_____

_____

_____

APPENDIX C

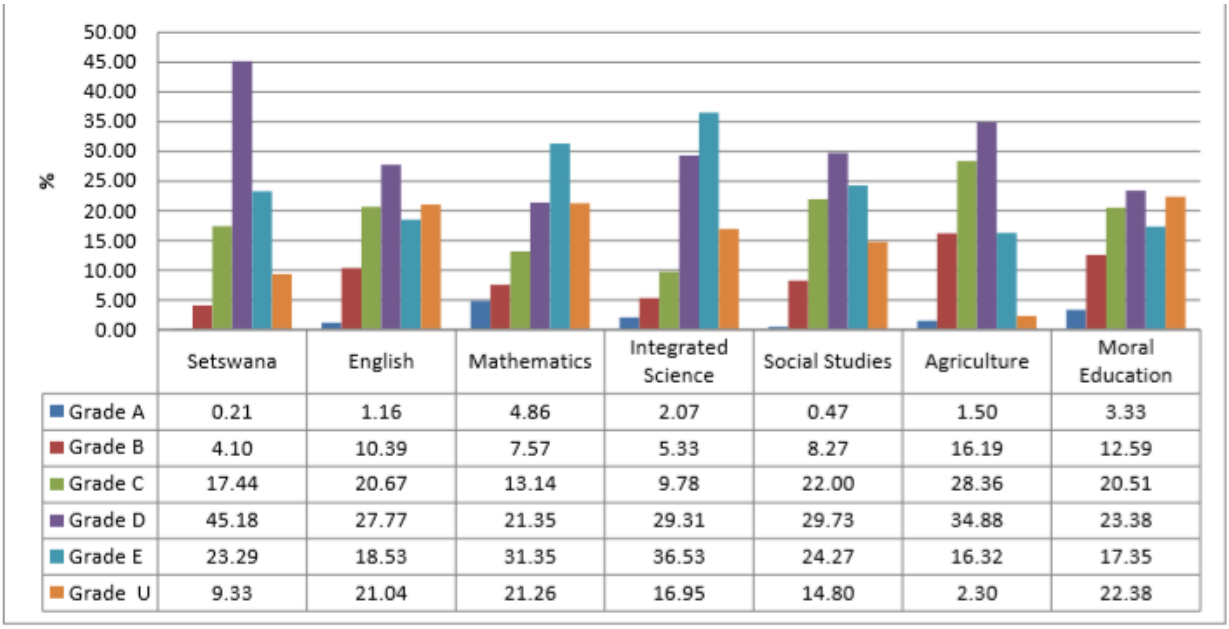
CLASSROOM OBSERVATION (Non- participant observation)

The researcher will observe each teacher teaching one session with the intention to find out: How ICT is deployed in the teaching of mathematics at Junior Secondary schools, how their deployments facilitate the teaching and learning process at Junior Secondary School level?

The researcher will keep an eye on the following key areas.

- What ICTs are used by the teacher in the teaching and learning?
- How is each ICT used in the teaching and learning of mathematics?
- Does the teacher have access to technology and use during lesson?
- Which educational technology is the teacher using during lesson?
- Are the students actively involved in using educational technology during lesson?
- How many students per ICT tool used during lesson?
- Does the school have mathematics laboratory and connected to internet?
- Does the school have computer laboratory and connected to internet?
- What ICT media are commonly used by teacher in mathematics?
- What are the ICT media used for?
- Are the teachers conversant with ICT tools?

Fig.1: Percentage of Candidates at Each Grade in Core Subjects



	Setswana	English	Mathematics	Integrated Science	Social Studies	Agriculture	Moral Education
Grade A	0.21	1.16	4.86	2.07	0.47	1.50	3.33
Grade B	4.10	10.39	7.57	5.33	8.27	16.19	12.59
Grade C	17.44	20.67	13.14	9.78	22.00	28.36	20.51
Grade D	45.18	27.77	21.35	29.31	29.73	34.88	23.38
Grade E	23.29	18.53	31.35	36.53	24.27	16.32	17.35
Grade U	9.33	21.04	21.26	16.95	14.80	2.30	22.38

Source: 2019 JCE Provisional Results Report, BEC, Botswana.

Figure: 1 presents proportion of candidates at each grade across core subjects. Mathematics and Integrated Science having the highest proportions at E

Table 1: Percentages of candidates awarded Grade E or better and C or better by subject in 2017, 2018 and 2019

	Grade C or better				Grade E or better		
	2017 (%)	2018 (%)	2019(%)	% Difference (2018/2019)	2018 (%)	2019 (%)	% Difference (2018/2019)
SETSWANA	15.90	19.04	21.75	2.71	90.30	90.22	-0.08
ENGLISH	29.29	29.58	32.22	2.64	80.75	78.52	-2.23
MATHEMATICS	26.20	28.60	25.57	-3.03	82.01	78.27	-3.74
INTEGRATED SCIENCE	16.80	18.97	17.17	-1.8	82.72	83.02	0.30
SOCIAL STUDIES	29.16	30.17	30.74	0.57	84.61	84.74	0.13
AGRICULTURE	40.57	42.10	46.05	3.95	98.46	97.25	-1.21
DESIGN & TECHNOLOGY	16.56	16.86	16.07	-0.79	82.89	82.24	-0.65
HOME ECONOMICS	28.49	27.48	29.24	1.76	92.91	92.17	-0.74
COMMERCE & OFFICE PROCEDURES	5.23	4.79	7.92	3.13	68.87	66.36	-2.51
COMMERCE & ACCOUNTING	17.59	18.79	20.02	1.23	71.96	71.22	-0.74
RELIGIOUS EDUCATION	32.66	31.15	31.89	0.74	82.68	85.40	2.72
ART	60.49	60.15	64.16	4.01	99.36	99.52	0.16
GENERAL SCIENCE	1.83	1.93	0.75	-1.18	65.95	57.55	-8.4
MORAL EDUCATION	39.60	38.47	36.42	-2.05	78.49	77.16	-1.33
FRENCH	13.61	16.17	17.28	1.11	68.23	67.03	-1.2
MUSIC	26.25	24.40	29.90	5.5	88.23	88.73	0.5
PHYSICAL EDUCATION	22.13	19.76	22.90	3.14	85.23	83.63	-1.6