THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGY BY MATHEMATICS AND PHYSICAL SCIENCE TEACHERS AT SECONDARY SCHOOLS

By

Thabo Garth Khomo

43425895

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Supervisors

Mr C. Pilkington

Prof. I. Sanders

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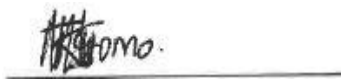
DECLARATION

I declare that **THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGY BY MATHEMATICS AND PHYSICAL SCIENCE TEACHERS AT SECONDARY SCHOOLS** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the thesis/dissertation to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.



Mr Thabo Garth Khomo

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ABSTRACT

Information and communication technology (ICT) advances have dramatically changed teaching and learning processes. This study investigates the use of ICT in teaching and learning with the objective of establishing whether teachers are utilising the skills acquired through the Sci-Bono Discovery Centre training. The study sample comprised of 30 secondary school teachers who were trained in 2012 and who were teaching mathematics and/or physical science. The participating teachers were from schools that fell within the Johannesburg North and Johannesburg East regions of the Gauteng Department of Education (GDE).

An overall understanding of reviewed literature on the use of ICT in teaching and learning contributed to the preparation of the research survey questionnaire and interview questions. A research survey design using a multi-methods approach allowed both questionnaires and interviews. The questionnaires were analysed using a simple descriptive data analysis technique. The interviews were conducted with 12 of the initial 30 participants over a period of two weeks in a one-on-one setting. The recorded interviews were transcribed and analysed using a thematic content analysis technique. The results of both quantitative and qualitative analysis are presented using charts and tables.

The research findings identified issues such as the need for teachers to maintain a positive attitude towards the use of ICT in teaching, and for schools to create a conducive teaching environment for effective use of ICT in the classroom, including the availability of computer resources. The study provides recommendations including the provision of ICT coordinators at schools, and the provision of an ongoing teacher ICT training programme.

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ABBREVIATIONSAND ACRONYMS

For this study, ICT refers to information and communication technology, including the broad uses of technology in schools (Cohen et al., 1996).

DoE	Department of Basic Education
ESSP	Extra School Support Programme
FET	Further Education and Training
GDE	Gauteng Department of Education
GoL	Gauteng Online
ICT	Information and Communication Technology
IT	Information Technology
MGSLG	Matthew Goniwe School of Leadership and Governance
PDoE	Provincial Departments of Basic Education
TDU	Teacher Development Unit
TPCK	Technological Pedagogical Content Knowledge
UNISA	University of South Africa
ICILS	International Computer and Information Literacy Study

CHAPTER 1: BACKGROUND

1.1 INTRODUCTION

ICT advances have dramatically changed teaching and learning processes. The availability of ICT infrastructure for learning and teaching at schools is gradually increasing, and many schools are taking advantage of ICT benefits to improve the quality of teaching (DoE, 2004). The pass rate nationally for mathematics starting from 2013 showed a significant drop from 59% in 2013 to 53% in 2014 to 49% in 2015. In physical sciences, the pattern is similar, from 67% in 2013 to 62% in 2014 and 59% in 2015. However, in 2016, the average results for mathematics and physical science subjects slightly increased from 49% in 2015 to 51% in mathematics and from 59% in 2015 to 62% in physical science.

In 2013, nine schools obtained a 0% pass rate, compared to 16 schools in 2014 and the number increased to 22 schools nationally in 2015. However, in 2016, the percentage showed a downward trend with 18 schools, which is still high compared to 2013 and 2014. Overall, these results are concerning due to this downward trending pattern. However, there are two ways to tackle this problem. The first one is to put in place programmes to help the learners and the second one is to put in place programmes to help the teachers.

One of the programmes to help the learners is the Extra School Support Programme (ESSP) introduced by the GDE in partnership with other government departments. It was implemented to enhance teaching and learning specifically at underperforming schools within the Gauteng province. The program aims to reinforce the work done by teachers for the learners without home support with their academic work. The ESSP officials undergo an accredited skills training programme that includes office administration and information technology. The programme seems to be assisting, as attested by the learners who partake in it (The eLearning Directorate, GDE, 2011).

The GDE also introduced programmes designed to assist the teachers in collaboration with two provincial training institutes. The first one is the Matthew Goniwe School of Leadership and Governance (MGSLG) and the second one is the

Sci-Bono Discovery Centre. These institutions provide teacher-training programmes. The MGSLG states that they aim to assist teachers to develop their content knowledge and teaching methodologies on *assessment* to better conduct an assessment for improved learning (The eLearning Directorate, GDE, 2011). On the other hand, the Sci-Bono Discovery Centre states that it aims to provide mathematics, science, technology, and computer training for all teachers Grade R to 12 that focuses on content mastery, assessment, and lesson plan delivery (The eLearning Directorate, GDE, 2011).

The Sci-Bono Discovery Centre also has support programmes that guide learners through a series of curriculum-based experiments and practicals in physics, chemistry, and life science. The collaboration between the GDE and the Sci-Bono Discovery Centre is to encourage the effective use of information and communication technology (ICT) in teaching and learning by providing teacher ICT training programmes. This research study focuses only on the technology and computer training programmes facilitated by the Sci-Bono Discovery Centre that are designed to help the teachers. Thus, the study investigated the extent to which the trained mathematics and physical science teachers are using their newly-acquired skills when teaching at their respective secondary schools. Skills that the teachers learn include the use of Microsoft Word, Excel, PowerPoint, and other ways to prepare lessons, tests/exams, and learning related activities using ICT tools.

Education plays an important role in society, and the traditional methods of teaching and learning are changing due to the introduction of technology in schools. ICT also has the potential to enhance the management and administrative capacity of schools. However, for the training to be beneficial, teachers need to be supported to work with technology by creating an environment in which they can learn, discuss, and analyse their own teaching experiences in the use of ICT with their colleagues (Mouza, 2011). Nevertheless, there might be potential barriers that need to be considered by the schools when they attempt to use ICT-based resources. The barriers can include inadequate access to the technology or technology-related training, lack of infrastructure, teacher attitudes and lack of resources (Donnelly et al., 2011).

Additionally, an important aspect of ensuring that ICT is used effectively is to deal directly with the attitude of teachers towards ICT, their perceptions about the importance of ICT, their philosophy about teaching and learning and their conception of knowledge (Galanouli et al., 2004). According to Mansour (2009), teachers need to identify certain challenges that obstruct them from changing their beliefs and practices, for example, the introduction of new teaching methods when there is pressure of exam preparations.

This chapter starts with an outline of the problem statement and then identifies the objectives of the research study followed by the main research question and the sub-questions. The chapter also gives a brief discussion of the research methods used for conducting the research, the research process, and the research results. The chapter further highlights the assumptions of the research study, followed by discussion of the limitations and scope of the study. The chapter concludes with a chapter outline that summarises each chapter of this research study.

1.2 PROBLEM STATEMENT

The use of ICT in education can present an opportunity to transform the education system, with some improvements and innovations that will result in greater efficiency (Bidarian et al., 2011). The objective of the training provided by the Sci-Bono Discovery Centre is to improve professional teacher practice in mathematics, physical science, and technology teaching in the General Education and Training (GET) and Further Education and Training (FET) bands. There appears to be a problem in that the skills that teachers learn are not being used when the teachers return to their schools. Govender and Dhurup (2014) argue that “the risks of not using technology in teaching are too great when considering the rapid pace with which knowledge is expanding and the need to compete globally in an information technology community of practice” (p1221).

This research study has investigated the extent to which Sci-Bono Discovery Centre-trained mathematics and physical science teachers at secondary school use the ICT skills they acquired, particularly when preparing and presenting their lessons. The

study also identified possible barriers to the adoption of the skills in actual teaching. The research focused specifically on mathematics and physical science teachers in some of the schools in two Gauteng province GDE regions, namely Johannesburg North and Johannesburg East.

1.3 RESEARCH GOALS/OBJECTIVES

The objectives of this research were:

1. To establish to what extent teachers utilise the ICT skills provided by the Sci-Bono Discovery Centre when teaching mathematics and physical science at secondary schools.
2. To identify possible barriers to the use of ICT in the preparation and presentation of subjects and lessons.
3. To determine where the barriers may emanate.

1.4 RESEARCH QUESTIONS

The main research question for this study is: To what extent are secondary school mathematics and physical science teachers using the ICT skills gained at the Sci-Bono Discovery Centre?

The research sub-questions are:

1. What are the teacher’s expectations of the training, and their toughts and views about what they learnt through the training?
2. What ICT resources do these teachers have at their respective schools?
3. What are the possible barriers which might inhibit them from utilising their newly-acquired skills and what could be done to overcome them?

1.5 RESEARCH METHOD

The researcher's philosophical stance for this research study is interpretivism. Neuman (2000) argues that interpretivist researchers interact with the objects under study and that a thorough analysis of the interview transcripts can lead to a deeper

insight of the transcripts under study. Nevertheless, they do not see their interpretations as beyond question.

The study used a survey research design with a multi-methods approach that allows for both questionnaires and interviews. According to Muijs (2010), this approach is flexible in that the research design is determined by what we want to find out. In this approach, quantitative and qualitative research methods are used in the same research study. The collected questionnaire data were used in the preparation of the interview questions.

The participants consisted of 30 teachers who teach mathematics and physical science or both from secondary schools in the Johannesburg North and Johannesburg East regions within the GDE. The participants were chosen because they had already attended the teacher ICT training programme at the Sci-Bono Discovery Centre in 2012. This was imperative since one of the objectives of this study was to look at whether trained teachers are utilising their newly-acquired skills when teaching and learning.

1.6 RESEARCH PROCESS

To ensure adherence to ethical research, the researcher applied for, and obtained, ethical clearance from the appropriate UNISA ethics committee. An application was made to the GDE's research unit to survey and interview the teachers and was approved. There were four phases involved in this study.

- The first phase was the sampling in which the Sci-Bono Discovery Centre was engaged to request the trained teacher information. The processes also involved seeking permission from the GDE to survey and interview the teachers.
- The second phase was the pilot survey in which the participants were engaged via their email addresses, which formed part of the information obtained from the Sci-Bono Discovery Centre but the approach proved ineffective as only one participant out of six responded. In telephonic follow-up, participants cited lack of access to the computer, printer, and internet as some of the factors that contributed to their inability to respond to the email. An ICT coordinator from a school in Soweto that has ICT resources piloted the questionnaire together with

five teachers from the school, and that proved successful. The five teachers were not involved in the Sci-Bono Discovery Centre teacher-training programme that took place in 2012. The teachers were only involved in the process of piloting the questionnaire, as their school did not form part of the 16 GDE approved schools that fall within the Johannesburg North and Johannesburg East regions.

- The third phase was to perform the actual survey where the researcher embarked on the process of personally distributing the survey questionnaire by visiting each participant at the 16 schools. The process proved successful as each questionnaire was distributed, answered, and collected immediately, and in two weeks the survey process was complete.
- The fourth phase involved conducting interviews in a one-on-one setting with 12 of the 30 participants that were recorded using a voice recorder and taking notes. Transcripts were made of the recorded interviews through a third party that provides transcription services and were evaluated and verified by the researcher upon receipt. Interview data were analysed manually using a thematic content analysis technique, which is a set of analytical techniques that employs systematic and objective procedures to describe the content of messages (Bardin, 2011).

1.7 RESEARCH RESULTS

The outcome of the analysis process presented in the research results chapter indicated low levels of ICT use when teaching. Lack of computer resources, limited access to the computer resources, and lack of computer support at schools were among some of the major reasons that contributed to the low levels of utilising ICT in teaching. Nevertheless, it was established that a small number of participants do use ICT in their teaching activities including for administrative purposes such as processing statistical data for learners who passed or failed and maintaining class registers and mark sheets. There were also participants who stated that they use the ICT tools to prepare exam/test papers and not for teaching purposes.

Furthermore, training results showed that most participants were happy with their training, and wanted it more often. A small number were of the opinion that the training was basic and they required an advanced form of training. Thus, the lower

levels of ICT use may be linked more to the unavailability of computer resources at school and support and less on the teacher ICT training programme as most participants felt that the training was adequate.

1.8 ASSUMPTIONS

Quantitative data were collected by survey questionnaire. At a later stage, interviews were scheduled with some of the participants to collect qualitative data. The interviews were conducted in a one-on-one setting and recorded with the interviewer also making notes. It is, therefore, assumed that the statements provided by the participants on surveys and during interviews were given honestly and not with an intention to mislead.

1.9 SCOPE AND LIMITATIONS OF THE STUDY

The study was limited to investigating the use of ICT in teaching by mathematics and physical science teachers at secondary schools (see Table 1.1). Participants were teachers trained at the Sci-Bono Discovery Centre in 2012 and they came from 16 different public secondary schools within the Gauteng province. The public schools formed part of the two regions within the GDE, namely Johannesburg North and Johannesburg East.

Table 1.1: Number of teachers per subject

Subject	Total number of teachers
Mathematics	23
Physical Science	3
Both subjects	4

The views of other key stakeholders, such as national policy makers, curriculum developers, school leaders, academics, and parents, who may have a direct or indirect influence on the use of ICT in teaching, were not covered. In as much as ICT has a broader definition and includes all types of hardware and a variety of software technologies, the research focused on the teachers' use of computer software tools such as Microsoft Word, Excel and PowerPoint when preparing and presenting

lessons. In the study, the researcher focused on identifying the challenges that may inhibit or enable the use of ICT in teaching and their outcomes as well as teachers' own experiences and how they use and implement ICT when preparing and presenting their lessons. Due to the small sample of participants, the findings of this research will only relate to the participants of the study and may not be generalisable to the other schools or academic subjects.

1.10 RESEARCH CHAPTER OUTLINE

This research study document is composed of six chapters.

Chapter 1 is the introductory chapter. It delineates the problem statement, research objectives, research questions and sub-questions, and the assumptions and limitations of the study.

Chapter 2, Review of the Literature: discusses the existing literature by focusing on what other scholars have written about the use of ICT in teaching and learning both locally in South Africa and internationally.

Chapter 3, Research Methodology, presents the research framework, which introduces and critically examines the set of theories to be used in the study, namely the interpretivist research framework. The chapter further explains the sampling process, data collection methods, as well as the analytical tools that were used to analyse the collected data.

Chapter 4, Results: presents the research findings that were derived using descriptive data analysis techniques with charts and tables for the quantitative data component and the thematic content analysis technique for the qualitative data component.

Chapter 5, Discussion: interprets the research results and highlights the issues for consideration and improvement that arose from the research findings, and provides responses to the research question and sub-questions.

Chapter 6, Conclusion: presents a summary of the research study, research findings and highlights topics for further research. The chapter also provides recommendations for the effective use of ICT in teaching.

CHAPTER 2: REVIEW OF THE LITERATURE

2.1 INTRODUCTION

The purpose of this chapter is to look at what other scholars have written about the use of ICT in teaching and learning, to establish the framework for this research. Thus, the researcher reviewed different types of literature: articles, journals, and books. This chapter has sections that focus on ICT use in teaching and learning, benefits, barriers to ICT use, ICT policies, teacher support, change management, as well as teacher training.

The chapter begins with a discussion of ICT use in teaching and learning and the rationale behind it, particularly in schools. It further explores the benefits and the challenges involved when using ICT in teaching and learning. It presents a brief discussion of ICT policies with specific focus on the national and the provincial departments of education. After that, a discussion of teacher support is followed by a view of the change management processes required to manage the transition of teachers from the traditional methods of teaching to those that use ICT. The chapter concludes by presenting a discussion on the ICT training programmes that are on offer to the teachers and their effectiveness when used for teaching purposes.

The research described in this dissertation builds on this literature concerning the challenges that the teachers encounter, benefits that they derive from using ICT, the need to change management processes, and the support required by teachers, including training.

2.2 ICT USE IN TEACHING AND LEARNING

According to Carlos and Yinon (2006), research indicates that while some teachers might have applied technological tools to good effect, others are focusing on using them only for emails, internet access, and PowerPoint presentations. The question is how many of them use these technologies efficiently to improve teaching and learning. The use of technological tools for teaching and learning purposes is becoming increasingly widespread as their potential is recognised and new demands are constantly made on teachers (Assareh & Bidokht, 2011). Drossel et al. (2017)

argue that the teacher's expertise in using ICT for teaching and learning purposes is on average linked with the usage frequency per week. Frequently using ICTs in the classroom may enhance the quality of education by helping teachers to do their jobs more effectively.

Bidarian et al. (2011) state that it is necessary to have a new teaching framework with enough emphasis on technology, which may lead to improvements such as the development of education at all levels. Suarez-Rodrıguez et al. (2018) argue that teachers have a decisive role to play for the success of ICT integration in the classroom because the process cannot take place or succeed without their collaboration. However, according to Khokhar and Javaid (2016), in developing countries, ICT use in teaching brings challenges (discussed in the barriers section), which if not addressed may influence how successful the integration can be when measuring the teaching and learning outcomes. In recent years, technology integration has transformed the traditional conception and contextualisation of the classroom (Mustafa, 2014).

Howell (2012) argues that with advances in technology, such as mobile devices, laptops, wireless networks, and Wi-Fi the rate of ICT uptake and the success at a school varies depending on the level of organisational support that schools receive. ICT is a tool that can support learning across the curriculum including presentation, computer projection and various activities such as recording marks, preparing lesson plans, data capturing, and publishing. Conversely, Fernandes et al. (2018) assert that despite increased access to computers, teachers continue to use ICT mostly for formal academic tasks, such as obtaining information from the Internet or administrative purposes such as developing lesson plans, worksheets, and assessment tests and not as a tool to support active learning. Hinostroza (2018) expressed a similar view and stated that regardless of the investment in equipping schools with computers and the Internet, the use of ICT in teaching and learning activities is happening much more often outside the classroom context. Furthermore, most frequent activities are those related to lesson preparation, such as creating resources and using the Internet to search for and gather material. The aim of modern education must be to encourage interactive learning conditions where

teachers can use technological tools that develop skills of learning, self-assessment, cooperation, and acceptance of different points of view (Cunska & Savicka, 2012).

2.2.1 An approach to ICT use

According to Howell (2012), simply placing a computer into a classroom does not make the learning effective: teachers need to understand how to use technology effectively, understand the learning theories behind the practice, and know how to select the right technology for the learning outcomes they seek. ICT has to be viewed as an essential aspect of teaching and learning that can afford the teacher a new transformative way of development in the 21st century (Leach, 2005). Pradhan (2014) argues that a teacher is expected to know how to successfully integrate ICT into his/her subject area to make learning more meaningful.

Tedla (2012) noted that without the teachers' pedagogical expertise, ICT resources availability could not necessarily guarantee effective implementation in teaching and learning. Teachers need a digital pedagogy, which is the study of how to teach using digital technologies because they are expected to facilitate learning and make it more meaningful rather than just to provide knowledge and skills (Howell, 2012). Building on the framework of pedagogical content knowledge (PCK), Mishra and Koehler (2006) introduced a new concept called Technological Pedagogical Content Knowledge (TPCK), which was developed to address problems arising from an emphasis on teachers having technological knowledge for teaching purposes. They further argue that TPCK has three primary components that form the bases for the knowledge required by teachers for successful ICT use in teaching and learning namely technology knowledge, pedagogy knowledge, and content knowledge. According to Suarez-Rodriguez et al (2018), teachers should consider both the technological and pedagogical components and feel confident about using ICT in their teaching and learning activities because both are essential for the success of using ICT in the classrooms.

According to Hadjithoma and Karagiorgi (2009), a four-stage process for the successful use of ICT in teaching and learning was introduced in Cyprus. The process comprised:

- Innovations to respond to new challenges as new methods of teaching are introduced.
- Habitualisation to respond to and resolve particular problems that may arise so that teachers may follow a formalised policy and procedure for using ICT in the classroom without having to engage in a decision-making effort.
- Objectification to develop a socially shared meaning of specific and generalised behaviours, and to form a consensus about the value of the new methods of teaching and learning.
- Sedimentation to invest in the new teaching and learning methods with a view to establishing historical continuity.

This process encouraged teachers to strive to fit ICT into their existing context and view it through the legitimate rules and practices that are included in their institutions. Therefore, teachers were able to look at the use of ICT in their teaching activities as a tool that has been institutionalised in the education system (Hadjithoma & Karagiorgi, 2009).

2.2.2 Current levels of use in South Africa

Govender and Dhurup (2014) in the study that comprised 1222 teachers employed in public secondary schools in the province of KwaZulu-Natal in South Africa discovered that availing ICT resources to the teachers is not sufficient to ensure use instead measures must be put in place that will ensure teacher confidence to use those resources. The Gauteng province, which is where the schools in this research are located and the Western Cape province, “have a policy of implementing ICT in education into every school and have made progress in implementing ICT” (Howie & Blignaut, 2009:348). Nevertheless, Isaacs (2007) argues that a variety of interventions using tested models in ICT access, digital content development, and teacher training, just to mention a few, have led to a 22% ICT penetration in all public schools. However, the list of reasons not to use technology can be endless.

Effective ICT implementation in schools is a complex process that involves teachers' ICT competency, the readiness of the schools, financial support, curriculum review and government support concerning the provision of ICT infrastructure (Govender & Dhurup, 2014). Regarding ICT implementation in education, South Africa has made

progress but many schools are lagging behind, and the ones that have access are still trying to integrate ICT into their teaching and learning (Howie & Blignaut, 2009). This slow pace of ICT implementation may be attributed to the barriers, which Ertmer (1999) categorised into external and internal groups of barriers and they are discussed in detail in the barriers section. Draper et al. (2008) argue that some of the challenges are that class sizes are large and inadequately resourced. Furthermore, teacher practice needs a fundamental change that includes designing professional development programmes specially tailored for the training teachers on using ICT in the classroom.

2.2.3 Current levels of use in the rest of the world

The International Computer and Information Literacy Study 2013 (ICILS 2013) reveals that the use of ICT in the teaching and learning process is extensive, with three out of five secondary schoolteachers (international average) using computers at least once a week (Fraillon et al., 2013). The Malaysian government introduced the Smart School Initiative in 1996 that provided certain schools with ICT resources and coordinated change towards integrating ICT in teaching and learning. These initiatives helped the government to understand the advantages and disadvantages of introducing ICT into education (Kader, 2007). This is supported by a survey conducted in Malaysia by Singh & Chan (2014) which discovered that teachers were comfortable with using technological applications such as spreadsheets, application software, Internet and emails for their teaching and administrative activities. Korea defined its first Master Plan for ICT in Education in 1996, which was driven by their vision for developing a 'smart society' in the country with the main goal of establishing the required ICT infrastructure in the country (Hinostroza, 2018).

In Pakistan, a recently conducted study by Khokhar and Javaid (2016) that focused on secondary schoolteachers established that, although teachers have access to computers in schools and at home, the pace of ICT integration in the classrooms for learning purposes is slow. They further argue that Pakistan implemented a rigorous review process of the teacher education programme that started in 2004 and concluded in 2009 that resulted in changes in teacher training at the national level, and provided resources for both teacher education programmes and schools. This

review process also introduced standards that compel teacher-training institutions to equip teachers with the skills to use different educational technologies, both hardware and software.

According to Ramma et al. (2017), in Mauritius, technology is overwhelmingly employed in education as a tool to obtain information as opposed to being a tool that is used for knowledge construction when teaching and learning. They further noted that the use of technology in the classroom is no longer a debatable issue, and cannot be ignored as it has already permeated all spheres of their lives. According to Tedla (2012), from an African country's perspective, Rwanda adopted the one laptop per child initiative in 2007, and developed the ICT infrastructure and mechanisms to observe learner's interactions with the laptops (Hinostroza, 2018). In East Africa, lack of ICT integration is influenced by several interrelated factors, which may be categorised as manipulative and nonmanipulative teacher factors. Manipulative factors relate to the teachers themselves and may include skills, the commitment of teachers and ICT knowledge. Nonmanipulative factors relate to national policy, ICT training and external support. He further argues that governments in East Africa are more conscious about the importance of ICT use. Where the schools fail to provide ICT materials, teachers are expected to endeavour to get them on their own, for example, borrowing a laptop and other multimedia tools from the city.

The low levels of ICT integration in most African countries are due to factors such as low morale, the absence of pre-service and in-service training, ICT deficiency regarding the poor teacher training, and support (Tedla, 2012). Kiptoo et al. (2017) assert that in many African countries, the major obstacles to the use of ICT in schools are the lack of well-trained teachers and low levels of teachers' ICT skills and knowledge. They further observed that it would thus be difficult to implement ICT in schools without well-trained personnel that have the correct skills.

Across European countries, the use of ICT in teaching and learning has been identified and emphasised as a significant priority (Jimoyiannis, 2010). Educational reforms in Norway are compelling teacher-training institutions to incorporate training on using ICT in their curricula, and this has brought a change in their teachers' ability to integrate ICT in teaching and learning and has become widespread within the

country (Tømte, 2013). Turkey developed initiatives on a national scale by putting interactive whiteboards in 84 000 classrooms and tablet computers in the hands of more than 63 000 learners in grades 5 to 12 (Hobbs & Tuzel, 2017). However, the availability of teachers with knowledge and skills to integrate technology into the curriculum was limiting the effectiveness of the programme (Hobbs & Tuzel, 2017).

According to the ICILS (2013), in recent years, several Latin American countries have increased their focus on the use of ICT in the classrooms and also brought in a concept of one computer per learner in schools, which they commonly refer to as one-to-one resourcing (Fraillon et al. 2013). Argentina, Brazil, Chile, Peru, and Uruguay are amongst some of the countries that have implemented the one-to-one resourcing policies. However, Constantino (2014) argue that, because of a lack of institutional support, the traditional teaching model prevails in that even though alternative models do exist, the blooming and evolution of educational technology has not brought about significant changes. Most difficult for the poorest countries is the challenge to embed ICT (costs for hardware, software, continuous upgrades, training, and technical support) into education.

In a study that looked at six diverse public schools in the state of New South Wales, Australia, it was found that the government introduced a comprehensive programme to support schools (Hayes, 2007). The programmes included the provision of regularly updated computer hardware and software; connection of all schools to the internet; provision of training and development of teachers in the use of computers; and the development of curriculum support materials to enhance curriculum. The ICILS 2013 report indicates that in Australia, the teacher's weekly use of ICT in teaching was standing at 90% and at 80% for teachers in Denmark and the Netherlands, with Germany at about 66% and Poland only 40% (Fraillon et al. 2013).

2.2.4 Mathematics and physical science with ICT

ICT enhances the understanding of basic concepts and can make the learning environment alive and more interesting when used in teaching mathematics (Cunska & Savicka, 2012). However, some teachers are of the view that the use of ICTs takes the excitement out of learning mathematics just as calculators take away the

efforts required for leaners to build complex mathematical concepts (Makonye, 2017). Institutions have developed teaching models for the use of ICT in teaching and learning subjects such as mathematics and physical science. They include technology, teaching methodology, learning objectives, learning resources and tools (Sanchez et al., 2011).

The teacher's ability to integrate computer technology effectively in this new environment depends on their knowledge about technology (Roschelle et al., 2000). In Malaysia, preliminary observations of the introduction of laptops in the teaching of mathematics and physical science in 2003 found that teachers are not fully utilising these facilities in their teaching (Keong et al., 2005). ICT can contribute to effective interactive methods of teaching and learning mathematics, which promote creative thinking and participation in the educational process. Keong et al. (2005) developed an e-portal for the teaching of mathematics that consisted of two modules: a resource repository and a lesson planner. The resource repository was a collection of mathematical tools, a question bank, and other resources in digital form and the lesson planner was a user-friendly tool that can integrate resources from the repository for lesson planning. This e-portal helped teachers to plan their lessons daily and relieved them from their daily routine administrative tasks by providing them with some ICT resources during teaching.

In the South African context, the National Department of Basic Education has since 2009, rolled out *HeyMath!* in five provinces namely, Free State, Northern Cape, Limpopo, KwaZulu-Natal and the Western Cape. *HeyMath!* “is a range of information-rich animated lessons, interactive tools, maths lab activities, games and stories that engage learners in the difficult concepts of mathematics” (Motswai, 2017:26). It supports South Africa’s mathematics curriculum all the way from Grade R (entry level of schooling) to matric (senior level of schooling). However, the *HeyMath!* product has not yet been rolled out to the GDE schools, which is where the schools in this research are located. There are certain organisational conditions of interactive learning that should be followed in mathematics lessons (Cunska & Savicka, 2012). Some of the conditions are:

- Relations between the teacher and the learners should be positive and based on confidence;
- Style of teaching should be democratic;
- The process of cooperation between the teacher and the learners should be observed;
- Everything should be based on personal mathematical experience, and striking examples, facts and examples should be included;
- Introductory tasks should be included, and there should be enough time for doing basic tasks;
- A variety of educational methods and forms of giving the information, with regular, and purposefully based changes;
- The lesson should not be too complex, and using only some interactive methods;
- The methods used should correspond to the learners' age;
- Include definitions of activities;
- Take into account the speed and abilities of every learner;
- Create reflection on activities and promote discussion by doing mini question-and-answer sessions.

Draper et al. (2008) argue that when it comes to the use of ICT in physical science classrooms, South Africa faces considerable challenges in education as a whole with only 11% of schools having functioning science laboratories. In physical science classrooms, the use of images, videos and programmes or applications could contribute to a deeper understanding of the principles and concepts of science (Kelleher, 2000). ICT when teaching physical science can enable the collection of science information and interaction with resources, images and videos, and encourage communication and collaboration (Bingimlas, 2009). Al-Alwani (2005) argues that ICT can expand the pedagogical resources available to science teachers. According to Kelleher (2000), ICT use in the classroom could provide new, authentic, interesting, motivating, and successful educational activities, even though it cannot replace normal classroom teaching.

2.2.5 Teacher attitudes towards ICT

Teachers' attitudes are a major enabling/disabling factor in the adoption of technology. Development of a positive user attitude towards ICT adoption is essential not only for enhancing computer integration but also for avoiding teachers' resistance to computer use in the classrooms (Govender & Dhurup, 2014). Researchers have identified the traditional way of transmitting knowledge as a problematic issue to ICT use in teaching and learning. According to Howell (2012), teachers are still in some cases comfortable with the old teaching methodology, and reasonably so because they still lack the basic materials such as proper blackboards in the schools. Ramma et al. (2017:5) state that the affective domain, which is "a paradigm shift", is an essential factor that could help to deal with the teacher attitudes, feelings, and moods towards ICT use in teaching. Teachers' attitudes towards ICT have been found to be among the major factors that impact or influence the use of ICT in teaching and learning (Wario & Viljoen, 2015).

In a study conducted by Assareh and Bidokht (2011), the results showed and acknowledged that computers were not necessarily a replacement of the face-to-face and traditional methods of teaching and learning. However, computers were viewed as providing more choices, a better understanding, and improvement of the quality of teaching and learning. The teachers' philosophy about teaching and learning has been identified as one of the influencing factors to ICT use in the classroom. According to Tedla (2012), influencing factors refer to the teacher's attitude towards the use of ICT, the teachers' knowledge and skills about ICT and the school's commitment to the implementation process. ICT offers ways in which teaching and learning in the classroom can be improved and makes it easier to prepare tests or exams, and process and store marks. However, teacher's beliefs of the importance of ICT towards teaching and learning can greatly influence their perceptions of the effectiveness of ICT use in teaching (Shin et al., 2014). Prestridge (2012:449) noted that "teachers form their own beliefs about the role of ICT as a teaching tool". It would, therefore, be more important to assure teachers that ICT use can serve to improve the standard of teaching and learning as opposed to derailing it. These beliefs are referred to as "suppositions, commitments, and ideologies", and

they stem from emotive and affective evaluations including personal experiences, which are not open to outside appraisal or review (Prestridge, 2012:450).

The levels of prior knowledge and skills might also have a direct influence on the teachers' attitude towards ICT use in teaching. Teachers may hold their own set of beliefs that may determine how teaching and learning should be conducted (Govender & Dhurup, 2014). According to Shin et al. (2014), the teachers' likelihood of using ICT successfully is substantially related to their attitude towards technology. Hobbs and Tuzel (2017) in a recent study state that teachers who advance the use of ICT in teaching and learning have a positive set of attitudes and habits that influence their motivations to use technology for learning.

The teachers' role in the 21st century classroom has shifted, and it involves an essential mission, which is to be the frontier for applying technological innovations to the teaching and learning process (Goktas et al., 2009). Although the use of ICT in teaching and learning has many potential advantages, it is inappropriate to assume that its use will necessarily transform the way teaching is conducted (Bingimlas, 2009). Goktas et al. (2009) argue that the use of ICT is complicated because it does not involve only the use of alternative tools for dealing with the old problems but also expectations that the teaching, as well as the learning process, will be improved by these technologies. In studying the obstacles to the use of ICT in education, Bingimlas (2009) argues that the findings indicate a strong desire for teachers to integrate ICT when teaching, but that they encounter many barriers (refer to the section below that discusses barriers).

Technologies are still not yet fully integrated into the classroom, and their association with educational outcomes is yet unclear (Stewart et al., 2010). The use of ICT in teaching and learning can make the learning environment more attractive and applicable (Bidarian et al., 2011). Therefore, it is important that teachers as agents of change are ICT literate, as this could bring about a lot of positive attitude towards the use of ICT in the classroom (Singh & Chan, 2014). The research study conducted by Tedla (2012) shows that teachers who utilise ICT regularly in the classroom tend to develop the competencies and the necessary computer skills over time.

2.2.6 Teaching and learning methods

Chang et al. (2017) noted that generally, using ICT in teaching is complex and goes beyond simply using computers for instructions. In a modern pedagogical paradigm, because of the entrance of ICT, the learning process is centred on practical learning (Bidarian et al., 2011). ICT provides educational opportunities and readiness for classroom instruction and further promotes effective teaching and quality learning atmosphere (Tedla, 2012). The key indicators of the successful educational process are skills of thinking, working with information, solving creatively cognitive and practical tasks, competence in solving the problems independently and activity reflection skills (Cunska & Savicka, 2012).

True learning in modern times requires being able to use the latest technologies, not simply to enhance the ability to memorise facts but to collect, organise and analyse information to solve problems and innovate practical alternative ideas in real-world settings (Jimoyiannis, 2010). Teachers appear to have become more aware of the use of ICT in education and due to improvements in their technical skills over time, they may be sufficiently well-prepared on how to use ICT for pedagogical purposes (Tømte, 2013). According to Donnelly et al. (2011), issues to be considered for using ICT in teaching and learning may include the need to be mindful of the previous ICT initiatives in schools and how the current ICT use affects external ICT initiatives.

The use of ICT can only have a positive effect when the teaching and learning environment meet certain conditions. Those conditions may include sufficient access to technology, adequate training for teachers, an effective curriculum, relevant and pertinent evaluations, a stimulating educational system, and a motivating family and community (Sanchez et al., 2011). Valencia-Molina et al. (2016:13) argue that if teachers are to use ICT effectively within their teaching practice, they need to be well prepared and to deliberately create meaning around the use of ICT in education. These may include outlining a “learning itinerary” that focuses on learning from technology (instrumental use) and go on to a model towards learning with technology such as using technology to promote meaningful learning.

2.3 BENEFITS

This section explores the literature concerning the benefits that may be derived from using ICT in teaching and learning and discusses what some scholars have identified as the advantages of using ICT in the classroom. Research studies have been conducted to evaluate the benefits of using ICT in teaching and learning, and it was established that ICT positively contributes to the understanding of basic concepts and increased motivation for teachers (Tedla, 2012). Keong et al. (2005) identified greater collaboration, communication and the sharing of knowledge as some of the key benefits that can be derived when using ICT in teaching and learning. They further assert that ICT provides rapid and accurate data such as statistics that can contribute towards positive motivation for the teachers by simplifying their work.

Teachers' positive views of technology in education may lead to changes in activities in the classroom and influence the use of ICT in teaching and learning (Shin et al., 2014). Using ICT makes "teaching and learning activities more meaningful as ICT provides the element of interactivity that was never thought of before" (Umar & Jalil, 2012:5672). Bidarian et al. (2011) identified the following as the benefits of using ICT in teaching and learning.

- Revising and supplying of items: ICT could help to provide some of the teaching processes in a short time that may have taken a long time to do such as simulations.
- Access to information: Information can be easily accessed more especially for the schools that may be lacking resources such as laboratories.
- More variety and changes: The learning processes can be simplified and managed more efficiently, which may lead to an improved interactive teaching and learning environment.
- Cooperation: The teacher can use various platforms to collect information for teaching and learning purposes.
- Providing new educational position: Introduce more learning concepts on both theoretical and practical level.

- Focusing on different types of learning intelligence: ICT makes it possible to use different tools such as audio, video and visuals during the process of teaching and learning.

According to Jimoyiannis (2010), there are major benefits that can be drawn when ICT is used effectively in teaching and learning, which can lead to the significant educational improvement in schools. Makonye (2017) argues that the reluctance of educational institutions to embrace ICTs may lead to its unsustainability in the long term as ICTs offer a competitive advantage. By using ICT regularly in teaching and learning, teachers will gain extensive knowledge of computers beyond the use of ICT (Mustafa, 2014). Not employing ICT tools when teaching might lead to potential benefits not being realised (Bidarian et al., 2011).

2.4 BARRIERS

A barrier is defined as “any condition that makes it difficult to make progress or to achieve an objective” (Bingimlas, 2009:237). Goktas et al. (2009) define barriers as challenges that have to be overcome to attain a goal. The use of ICT in teaching and learning may be viewed as a significant improvement to the traditional methods of teaching and learning. However, there may also be multi-dimensional barriers to the usage of ICT in teaching and learning. Mustafa (2014) argues that teachers faced with barriers relating to the inclusion of technology may also introduce a new realm of discipline issues that can further complicate the already-complex nature of the classroom environment. Mustafa and Erginbas (2011) argue that the impact of technology use on classroom management brings about some new management issues. These issues may include the association between teachers’ technology adoption, managerial skills and the ways of keeping learners actively organised around learning tasks when using technology. Kiptoo et al. (2017) argue that the impediment to the successful use of ICT in teaching and learning is the inability of teachers to understand why and how they should use ICT in the classroom.

There is the challenge of how to integrate ICTs in teaching and learning activities, and some teachers who have not yet crossed the bridge argue that there is no need to use ICTs as they have always coped well without using them (Makonye, 2017). Singh and Chan (2014) argue that a daunting challenge facing the educational

system is the lack of trained teachers who are literate or proficient in the use of information technology. In the South African context, some of the factors that limit the effective integration of ICT in schools are poor internet connections, challenges relating to computer maintenance, affordability and lack of access to ICT technological tools like a computer, printer, or scanner (Draper et al., 2008). Fernandes et al., (2018) identified excessive workload, problems with managing learner behaviour and difficulties accessing computers and the Internet as some of the factors that inhibit the use of ICT. Mustafa (2014) argues that even when teachers have received ICT training, the effectiveness of using ICT for teaching and learning purposes will depend on the teachers' capacity and capability.

Galanouli et al. (2004) categorised barriers into two types, namely external and internal barriers. The external barriers, which are also referred to as extrinsic (first-order) barriers, relate to the educational institutions and internal barriers can be attributed to the teachers themselves, also referred to as intrinsic (second-order) barriers (Ertmer, 1999). Wario and Viljoen (2015) state that some of the first-order barriers are no longer perceived as insurmountable and can be easily addressed by securing additional resources. However, they further argue that since the second-order barriers are related to the teachers' attitudes, they are the most difficult to address but have to be addressed for effective use of ICT in the classroom.

2.4.1 Types of internal barriers

This subsection discusses various types of internal barriers.

- Lack of confidence. Bingimlas (2009) argues that this barrier is a contextual factor and is a major barrier to the uptake of ICT by teachers in the classroom. He further states that several research studies have highlighted the fact that this barrier prevents teachers from ever attempting to use ICT when teaching.
- Resistance to changing the traditional way of teaching. Galanouli et al. (2004) argue that resistance to change is a state of mind for many teachers and an effective obstacle for the successful integration of ICT in the classroom. Because of the teachers' core beliefs about education such as assessment types, teaching methods, organisation, and management, at times, changing old habits or breaking old practices is the most critical issue. According to Tedla (2012), this

particular barrier is deeply rooted in the school practices to the extent that it becomes difficult to convince trained teachers to change. However, not all beliefs are reflected in practice; there are many factors that may hinder teachers from putting their beliefs into action such as examination preparations and external influences like curriculum changes (Donnelly et al., 2011).

- Teachers' perceptions. Teachers will have their perceptions of how teaching should be conducted (Assareh & Bidokht, 2011). Therefore, placing technology in the classroom is just one-step; the key issue is the teachers' attitude towards implementing the technology in the classroom (Gedye, 2016). It would be important to try to convince teachers that computers are not necessarily a replacement for face-to-face contact and traditional classes, but tools that provide more choices, a better understanding of lessons and also help in improving the quality of teaching and learning. There is no doubt that any new technology use in teaching and learning depends on the values and beliefs of teachers about its importance or relevance for learning. Therefore, teacher support and encouragement by principals to fully utilise technologies is important (Robinson & Sebba, 2010).

2.4.2 Types of external barriers

This subsection discusses various types of external barriers.

- Lack of resources. ICT use in teaching and learning, as a recent educational innovation, is a complex process where many factors play a role. Lack of resources such as computer facilities, accessibility to internet and bandwidth can have a critical impact because some schools may have trouble in allocating funding to purchase or sustain their existing resources (Goktas et al., 2009). There is a wide range of disparities that exist between schools concerning ICT use as a significant tool in education. These disparities may include, among others, a limited number of computer facilities, unreliable access to electricity and limited technology infrastructure especially internet access, bandwidth, hardware, and software provision (Bingimlas, 2009).
- Lack of ICT policy. Government policy and the availability of external support may go a long way in ensuring the promotion of ICT use and integration into schools

that may lead to quality education (Tedla, 2012). Therefore, this barrier calls for a well-formulated national strategy and a solid policy on ICT use in the classroom.

- Lack of technology-related training. Most teachers might require training in the use of ICT when teaching but in some instances, complete computer literacy training may be required. This might be necessary especially if the teacher is an older person because he/she might be used to the traditional methods of teaching and learning (Cunska & Savicka, 2012). Some teachers may use ICT only for presenting the topic without direct application while other teachers may use ICT to facilitate learning for understanding a particular topic. The different methods of using ICT may be defined by the competency standards of the teacher that comprise three things namely technological literacy, deep knowledge and knowledge creation (Tedla, 2012). Furthermore, teachers need TPCK to be able to design and deliver effective teaching and learning programmes in a technology-enhanced learning environment (Mishra and Koehler, 2006). Training on computer skills needs to emphasise the use of those skills for teaching and administrative purposes since most teachers come from non-ICT-based teaching environments (Tedla, 2012). Even when teachers have attended ICT training programmes, there is no guarantee that they will utilise their newly-acquired skills in their teaching activities (Gedye, 2016). Therefore, an intensive ICT training programme should be provided on an ongoing basis to help teachers to learn new skills and improve their existing skills. During training, there needs to be guidance on how teaching and learning should be conducted using ICT.
- Lack of ICT tools. Challenges are constantly being made on teachers when it comes to ICT use in teaching, and they are increasingly becoming widespread (Assareh & Bidokht, 2011). Chen et al. (2012) argue that this barrier may result from inadequate and inappropriate configuration of ICT infrastructure, including access, time, support and resources. Due to lack of resources that may range from owning a computer and availability of resources such as overhead projectors and printers or scanners; some teachers may rarely use ICT in the classroom. According to Peterson et al. (2012), lack of infrastructure, course materials and technical support are the major issues in ICT facilitated learning.

2.4.3 Link between internal and external barriers

Other potential barriers to the use of ICT in teaching and learning include the following (Tedla, 2012):

- Unrealistic ICT policies
- Poor infrastructure
- Lack of teacher competence
- Lack of confidence
- Lack of incentives
- Teacher perception and beliefs
- Imposed curriculum
- Lack of proper network connections
- Sporadic electricity
- Lack of public awareness and participation
- Poor school leadership
- Technological illiteracy
- Lack of pedagogical skills.

These barriers are interconnected; for example, the lack of a proper network can be attributed to the lack of infrastructure barrier because it relates to the overall access to computer resources. Technological illiteracy is a barrier that is brought about by the lack of technology-related training, which is an extrinsic barrier and is discussed with other barriers under the extrinsic barriers section below.

This interconnectedness of the barriers also emerged during the research findings. The lack of resources and lack of ongoing training were presented as some of the challenges, which the participants highlighted, and when this two are combined, they may lead to the lack of confidence. This factor was further confirmed when one of the participants stated that if a teacher has access to a computer after the training, then it makes it easier for the teacher to utilise his/her skills. Lack of resources and lack of teacher competence is another interconnection of barriers that also emerged from the results in that one participant raised a concern that because of the lack of resources, s/he might be trained now and later forget because of not using the computers often due to their unavailability.

2.5 ICT POLICIES

South Africa has established a single national system of education, managed by the National Department of Basic Education (DoE) with the support of nine provincial Departments of Basic Education (PDoE). The administrative responsibility for the school sector lies with the Ministry of Basic Education and the PDoEs based on the national framework for school policy (Isaacs, 2007). According to Tedla (2012), ICT, like any other discipline, is in most cases taken as a separate subject by the learners and not as part of the curriculum. Therefore, policies need to be planned and developed to allow the use of ICT as a tool in the teaching and learning process. Tedla (2012) further states that the formulated ICT policies need to complement and support curriculum with technological infrastructure and ICT resources. According to Hinostroza (2018), countries need to draft policies that put an emphasis on creating support structures for ICT use, including technical and pedagogical support, with special attention placed on the use of ICT in teaching and learning.

Successful ICT use in teaching may depend on the school-related policies such as its ICT plan, ICT support, and ICT training. The policies should describe how to take up the opportunities and to address the limitations of ICT, and how to effectively integrate ICT into the schools and their broader sociocultural contexts (Jimoyiannis, 2010). Drossel et al. (2017) argue that the availability of an ICT school policy plan that offers advanced training activities for teachers such as in-service training could be one of the instruments that could be used to facilitate ICT use in teaching. Hinostroza (2018) states that in the late 1990s and early 2000s, most Latin American and the Caribbean countries developed their ICT policies, which included objectives about the provision of computers and Internet connections to schools and teacher training strategy. Chile created a Technical Assistance Network, based on a strategic alliance between the Ministry of Education and 24 universities across the country, whose main aim was to train teachers and provide them with technical and educational support. Kiptoo et al. (2017) noted that policies could fail, and some of the contributing factors might be when:

- The policies are viewed as symbolic gestures;
- Policy-driven change gets resisted by the teachers and viewed as being imposed on them without their input;

- Policies do not align with the teaching and learning methods;
- Teachers lack opportunity to learn about the policies and their instructional implications;
- There is a lack of resource alignment and policy monitoring.

According to Isaacs (2007), the government of South Africa developed a White Paper policy on e-education, the goal of which was that by 2013, schools were expected to have been developed into e-schools consisting of a community of both teachers and learners. E-schools were further defined among others as:

- Qualified and competent teachers who use ICTs to enhance teaching and learning
- Access to ICT resources that support curriculum delivery
- Connections to ICT infrastructure

However, South Africa still lags behind in ICT development; the government has made some attempts to address the issue including the establishment of the Presidential National Commission on Information Society and Development. Its objective was to act as an advisory group to the government on challenges regarding ICT development in South Africa and how the country could address these to be globally competitive (Govender & Dhurup, 2014).

2.6 TEACHER SUPPORT

According to Hayes (2007), ICT should largely integrate with ways to support and supplement existing classroom practices. The successful integration of ICT requires a fundamental shift in teaching and the core activities of schools. Nevertheless, ICT cannot be successfully utilised in teaching and learning without careful consideration of the existing infrastructure and human capital. This section consists of several subsections that look at support from different levels including the institutional, provincial, as well as school levels of governance.

2.6.1 Institutional support

Institutional support refers to the level of support that teachers receive from the national government, which is the DoE in the case of South Africa. This support may

include policy guidelines on training and the acquisition of computer facilities for the schools. Wario and Viljoen (2015) argue that teachers require institutional support, including the provision of intensive ICT training programmes to enable them to adequately master skills and knowledge about using ICT in teaching and learning. The level of institutional support plays an important role in determining the level of technology implementation in the classroom (Shin et al., 2014). Therefore, the integration of ICT is largely influenced directly and indirectly by this factor. However, in the absence of internet connectivity, the quality of the use of ICT for teaching and learning may be impacted (Isaacs, 2007).

2.6.2 Provincial support

The provincial support refers to the support given to teachers by their respective PDoE, which in this case is the GDE. Necessitated by the fact that ICT is no longer optional for teaching and learning, the PDoE in the Gauteng province in 2011 commissioned a study to establish guidelines on the management and usage of ICTs in public schools (The eLearning Directorate, GDE, 2011). The study proposed the implementation of teacher ICT training programmes in partnership with the training institutions, access to computer resources and applications, deployment of ICT coordinators at schools, and internet platforms namely Gauteng Online (GoL) laboratories. The basic infrastructure that was to be provided by the GoL laboratories included (The eLearning Directorate, GDE, 2011:43):

- Internet connectivity with email and website capability;
- A call centre to provide technical support to schools;
- Computer literacy training for teachers, administrators and learners; and
- Buses (mobile laboratories) with 20 workstations, TV & satellite connectivity, powered by own generators.

The study further discussed e-learning/e-education that was about using ICTs in the teaching and learning environment, e-maturity that focused on the extent to which ICT is used at schools, as well as e-readiness that checked the capacity of a school to use ICTs. The schools were rated on e-readiness scores, which included the schools' capacity to use ICT, the activities upon which ICT is used such as administration, preparation of lessons, teaching and learning (Table 2.1).

Table 2.1: Example of ICT usage at schools

School	Overall E-Readiness score (%)	Teacher usage of ICTs			
		Admin	Prep	Teaching	Learning
1	48	10%	26%	4%	25%
2	50	32%	26%	24%	26%
3	14	5%	3%	0%	0%
4	49	37%	23%	7%	2%
5	23	3%	9%	1%	1%
6	45	18%	19%	10%	18%
7	52	6%	22%	5%	4%
8	42	51%	21%	19%	14%
9	73	40%	25%	13%	16%
10	81	84%	57%	44%	33%
	Average for these 10 schools	28%	23%	13%	14%

Source: (The eLearning Directorate, GDE, 2011)

According to the report as highlighted in Table 2.1, ten schools were evaluated, and only two were found to have high overall scores for e-readiness, which are schools 9 and 10. The average usage of ICT for teaching and learning are at the lowest at 13% and 14%, which is even lower than the usages for administration (28%) and preparations (23%). The report further states that the schools could determine exactly where the development is required for the teachers at their schools by using a four-step process in teacher development (Table 2.2).

Table 2.2: Steps for teacher development in the use of ICT

Step	Steps in teacher development	Support required
1	Teachers understand the concepts and the basics of how to use hardware and key software	Basic training
2	Teachers are fluent in the use of computers, especially for core software such as word processing and use of the internet	Practice
3	Teachers can begin the classroom implementation process and develop an understanding of specific educational software	Subject specialist professional development
4	Teachers can use relevant educational software and general computer skills in their teaching and learning	Understanding of learning and how to mediate it

Source: (The eLearning Directorate, GDE, 2011)

The report concluded that schools would need to assess and identify each teachers' needs individually to access their ability to use educational software and the level of their ICT skills.

2.6.3 Local support

Local support refers to the support required at the school level such as school management including the school governing body, the principal, and the parents. Govender and Dhurup (2014) argue that for an effective ICT implementation, schools need to ensure teachers' competencies, schools' readiness to embrace ICT, availability of financial support, curriculum restructuring, and the adequacy of the ICT infrastructure. School facilities will strengthen the teachers' sense of ownership and help in changing their work patterns (Mustafa, 2014). Lack of support from the school can be an obstacle to instituting an extensive ICT integration practice in teaching and learning (Shin et al., 2014). The support given to schools to encourage the use of technologies and the amount of time spent accessing technologies impacts positively on the learning outcomes (Robinson & Sebba, 2010). Therefore, the provision of computer facilities at schools is vital and can have a significant effect on teachers' effective integration of technology into the classroom.

Bingimlas (2009) argues that although teachers do acknowledge the importance and value of ICT integration in teaching and learning, challenges in schools continue to be encountered during the process of adopting these technologies. Nevertheless, Howell (2012) asserts that schools are now equipping classrooms with more technology, and data projectors, computer points and interactive whiteboards are increasingly present in secondary schools' classrooms; hence the technology is there waiting for the teacher to use it.

2.6.4 Technical support

The acquisition of ICT coordinators for the maintenance of the ICT equipment at schools is an important factor that can facilitate the effective use of ICT in the teaching process (Assareh & Bidokht, 2011). The ICT coordinator has to be someone who can "champion" ICT in the school, drive its use by encouraging the teachers to use it in the classroom, in their management of administrative tasks and manage the computer labs, and perform system maintenance (The eLearning Directorate, GDE, 2011). Thus, the ICT coordinator has to be someone who is more knowledgeable than the teachers themselves are, and who can always be able and available to resolve teachers' ICT-related problems.

According to Howie and Blignaut (2009), 41% of South African schools have an ICT coordinator compared to 70% of schools internationally. They further argue that, on average, one out of two schools internationally use a teacher to provide technical support in contrast to the South African context where one out of four schools uses a teacher for the same task. This in their view, points to few teachers in South African schools having access to technical support. An ideal situation would be for each school to have at least one ICT coordinator, whose purpose would be to provide technical support to the teachers (The eLearning Directorate, GDE, 2011).

2.7 CHANGE MANAGEMENT

The teaching profession is evolving from an emphasis on teacher-centred instruction to interactive learning environments (Pradhan, 2014). According to Donnelly et al. (2011), the change process in schools should start with the individual teachers, to ensure that they understand the need to use ICT in teaching and learning. He further states that “reculturing” is necessary for effective educational change and can come about through the encouragement of the teachers to partake in the change process. However, it should also be noted that “It's hard to change teachers' beliefs” because some teachers are indifferent while some are technophobic when it comes to using ICT when teaching and learning (Bingimlas, 2009:235).

New concepts of learning have evolved due to the rapid changes in ICT, and for teachers to remain relevant and keep pace with new methods of teaching and learning, they need to adapt to change (Pradhan, 2014). The effective use of ICT in teaching and learning has the potential to be influential in bringing about changes in ways of teaching (Bingimlas, 2009). Changing from the traditional methods of teaching and learning may present the outcomes that include increased efficiency and positive effects on the educational system (Bidarian et al., 2011). Valencia-Molina et al. (2016) highlighted the need to make changes in all the areas in schools including technical, pedagogical, administrative, and managerial to attain the expectations around using ICT in teaching and learning. They further state that these changes will bring about an effective and efficient educational experience that promotes the teaching and learning process using ICT.

The presence of ICT in education has indeed changed the teachers' role in that they are no longer providing only knowledge but they are also facilitators. Many teachers are interested in effecting change in their classrooms (Mustafa & Erginbas, 2011). Valencia-Molina et al. (2016) argue that training institutions must recognise that the training of teachers in the teaching process should be based on research data that can provide guidelines, critiques, and methods of implementing ICT in the classroom. The following skills were identified as being vital to the success of incorporating any resource into the teaching and learning processes (Valencia-Molina et al., 2016:14).

- Psychoeducational skills: the capacity to create educational settings and generate experiences that promote concrete links with problems identified.
- Vocational and leadership skills: knowing how to impact, influence, listen, ask, explain and communicate effectively.
- Collaborative and cooperative skills: the ability to communicate and share information and knowledge with the view on improving the learning process based on the main ICT features.

Tedla (2012) argues that while the younger teachers tend to be motivated and determined to use technological materials in their classrooms, the older ones tend to do the opposite; the higher the age, the greater the reluctance becomes. Indeed, problems arise when teachers have to implement changes under unfavourable conditions but due to the importance of ICT in education, identifying possible obstacles (discussed in section 2.4) and addressing them may be an important step in improving the quality of teaching and learning (Bingimlas, 2009). A process is underway in most countries for a transition from the traditional educational models to one shaped by the demands of a digital society. This is a new order and a new development to help achieve outcomes that enhance the ability to compete in an increasingly demanding society (Valencia-Molina et al., 2016).

2.8 ICT TEACHER TRAINING

Teachers' ICT training, skills and access have a major influence on the use of ICT in teaching and learning, specifically in public schools (Kiptoo et al., 2017). Teachers need to acquire ICT skills and knowledge and be able to utilise those skills when

teaching. There can be effective ways of transitioning to and from computer activities, which may involve teacher training around classroom management and technology as well as positive teacher attitudes towards the use of technology in teaching and learning (Mustafa & Erginbas, 2011). According to Pradhan (2014), innovative technologies in recent years have created new possibilities for the teaching profession but have also brought with them new challenges for the teachers to learn how to use these technologies when teaching and learning. Training teachers in how to implement ICT in their teaching activities is a process that requires intensive training, which considers the various fields into which the technology will be integrated (Fernandes et al., 2018).

For ICT use in the teaching and learning process to be successful, thorough preparation and training of teachers have to be done (Singh & Chan, 2014). Working with ICTs may not be an easy task simply because ICTs are new and individuals, including teachers, have to be trained in using them. Therefore, an ongoing process of training teachers in the use of ICT for teaching purposes would be far more important than a once off training programme because it will serve as a tool for enhancing effective instruction (Tedla, 2012). Galanouli et al. (2004) argue that for the models of ICT teacher training programmes to succeed, certain issues need to be addressed, including provision of sufficient time, good technical and social support, and good equipment and resources.

2.8.1 Training offered

Jimoyiannis (2010) argues that training workshops should focus on improving or developing the teachers' skills in using certain educational software tools to help them to understand how ICT can enhance teaching and learning in specific subjects. Pradhan (2014) highlighted the following guidelines to be considered when offering the teacher ICT training programmes.

- There is no single best practice or general approach to success.
- Training should be flexible in terms of accessibility, mode of delivery and content.
- Teaching practice must be done differently from the traditional methods of teaching and learning.

- Teacher development should be managed and followed up to see if there are training gaps.
- Essential training programmes should be undertaken when the need arises.

According to Donnelly et al. (2011), teachers put a greater emphasis on learning about a particular ICT rather than learning with it. Training must emphasise the importance of learning with ICT instead of learning about them. Teacher ICT training initiatives tend to focus on the technology aspect, like how to use various tools. The pedagogy and instruction issues such as why and how to use ICT tools to improve learning are being ignored (Jimoyiannis, 2010). This may lead to the use of ICT in schools being driven by the affordance of technology instead of pedagogy and subject matter.

In many respects, the preparedness of the trained teachers may not be quite at a standard that would be expected, and they often feel unprepared to make effective use of the many educational technologies that they get (Nelson, 2006). Pradhan (2014) argues that most teacher ICT training programmes provide courses in basic ICT knowledge and skills. Constantino (2014) expressed a similar view about the training given to practising teachers, that the training is not adequate to enable teachers to incorporate ICT efficiently into their classroom activities. The teacher-training institutions, specifically in Africa, continue to teach more about what is ICT instead of how to use ICT during teaching and learning in the classroom (Kiptoo et al., 2017). The duration and intensiveness of the training programme can have a positive impact in changing teachers' attitudes towards the use of technology in teaching (Fernandes et al., 2018).

2.8.2 Effectiveness of the training

It is necessary for teachers to become skilled in operating the new technologies and exploiting them effectively as educational tools. For the training to be effective, it needs to respond to particular needs, interests, and contexts within which teachers use ICT. Trainers need to also consider the individual differences and offer flexible, responsive training programmes and modules (Pradhan, 2014). Wong (2007) indicates that a three-module course, called functional IT, was developed within the pre-service teacher-training programme in the Bhutanese teacher-training

institutions. The programme was meant to equip teachers with ICT skills that would help them to prepare instructional materials. He further argued that the programme succeeded in bringing about changes in the area of teacher ICT training, and teachers' skill and knowledge improved significantly.

2.9 CHAPTER SUMMARY

This literature review chapter presented a discussion about what other scholars have written about the use of ICT in teaching and learning. The chapter started by discussing ICT use in teaching and learning, which established that it can enhance the quality of education by assisting teachers to perform their work more effectively. Teachers were found to be using ICT for predominantly administrative purposes such as lesson plan development, class registers, and assessment tests instead of in the actual teaching. An approach to ICT use subsection outlined factors that teachers are expected to know in order to successfully use ICT to make learning more meaningful. As part of the approach to the successful use of ICT in teaching and learning, a four-staged process introduced in Cyprus was presented and it resulted in teachers being encouraged to strive to incorporate ICT into their teaching activities. The issues of large class sizes and inadequate ICT resources at schools were identified as some of the challenges within the South African context. Internationally, a 2013 report by ICILS revealed that Australia, Denmark, Germany and Netherlands were amongst the highest ranked nations in terms of the teacher's weekly ICT usage levels with averages of over 80%. Conversely, from the South African perspective, a 2011 study that was commissioned by the GDE eLearning Directorate showed that more still needed to be done as far as the usage levels per week were concerned. The chapter also showed that countries such as Malaysia have made great strides in getting their teachers to use ICT in teaching while some African countries were still experiencing various challenges. In Europe, it was noted that countries such as Norway are compelling their teacher-training institutions to include the use of ICT in teaching as part of the curricula. The chapter discussed the teaching of mathematics and physical science using ICT and highlighted some organisational conditions of interactive learning that need to be followed specifically for mathematics lessons. Teacher attitudes towards ICT such as the teachers' philosophy of teaching and learning were highlighted as some of the major

influencing factors. It was also noted that some teachers viewed the use of ICTs as taking out the excitement out of the learning process. Adequate training of the teachers was highlighted as one of the factors that could enhance the role of a teacher in an ICT classroom. However, the chapter acknowledged that despite the benefits that could be derived from using ICT in teaching and learning there are barriers that can be encountered.

The chapter explored some of the various types of barriers that may be encountered when teachers are using ICT in their teaching activities. The barriers that were discussed were categorised into internal and external barriers. Internal barriers were found to be linked to the teachers themselves, for example, lack of confidence, which needs the teachers themselves to deal with it individually. The external barriers were found to be the type of barriers that are linked to the institutions, and they included the lack of facilities or resources, lack of technology-related training, lack of ICT policy, and lack of ICT tools among others. However, other barriers such as lack of computer resources and support were found require intervention from the relevant educational institutions. The chapter further discussed ICT policies that should be put in place for the successful use of ICT in teaching and learning both locally in South African and internationally. It further highlighted some factors that may contribute to the failures in using ICT for teaching and learning.

Ways to support the teachers and supplement the existing pedagogical practices for the successful use of ICT in teaching and learning were outlined in this chapter. They were categorised into four different levels, namely institutional, provincial, local and technical levels of support. The institutional support was highlighted as a critical element of support that should be provided for by the national government to the schools and could play an important role in increasing the level of ICT use in teaching and learning. The provincial support which needs to be provided by the PDoE was also discussed whereby the guidelines on the management and usage of ICT in schools that were highlighted. Local support, which refers to support from the school management was identified as being critical to ensuring the successful implementation of ICT use in teaching and learning. The last level which is technical support was highlighted as also critical including the deployment of ICT coordinators at schools. In terms of the international standards, the South African schools were

demonstrated to be lacking regarding the providence of teacher technical support compared to other schools in the world.

The chapter further highlighted the change management processes that were also termed “reculturing” for an effective educational change process to encourage the teachers to welcome the new methods of teaching and learning. It was argued that the process should start with the individual teachers to ensure that they understand the need to use ICT in their teaching activities. The chapter concludes with a discussion about the teacher ICT training, focusing on the type of training offered to the teachers and its effectiveness. It identified the five guidelines that should be considered about the implementation of teacher ICT training programmes. The need for the teacher-training programmes to emphasise the importance of learning with ICT as opposed to learning about them was highlighted as being essential for the success of using ICT in the classroom. The specific focus was also given to the intensiveness of the training and whether it responds to the particular needs, interests and contexts within which teachers use the ICTs. It was further argued that the training programme(s) offered to teachers need to focus on basic ICT knowledge and skills.

The next chapter discusses the specific details about the type of training on offer and how participants for this research study were selected. It further discusses the research methodology; the data gathering techniques and the ethical issues involved in the research study that involves human participation.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

Chapter 1, Introduction, presented an overview of the problem statement, the objectives of the research study, the research questions and noted the assumption that the answers were provided by the teachers without any intention to mislead. Chapter 2, the Review of Literature, focused on what other scholars have reported about the use of ICT in teaching and learning both in South Africa and other parts of the world. The chapter further presented literature on various aspects including ICT use in teaching and learning, benefits, barriers to ICT use, ICT policies, teacher support, change management as well as teacher training.

This chapter, Research Methodology, presents various sections that include the steps undertaken to acquire and analyse the data about the extent to which teachers trained at the Sci-Bono Discovery Centre use ICT in teaching and learning. It begins with the philosophical underpinning that guided this study and considers what it means for this particular research and how it influences it. The chapter also presents the discussion of the research design that was used, which is a survey research design that uses questionnaires and interviews. The sampling scheme that was followed in selecting the participants is highlighted and discussed. The chapter further discusses how data were gathered and the tools that were used when analysing it. The chapter concludes by discussing research ethics, with a specific emphasis on the ethical issues that should be considered in this particular research study, which involves human participants.

3.2 PHILOSOPHICAL ASSUMPTIONS

Philosophical assumptions in all research studies, whether qualitative or quantitative, are about what constitutes “valid” research and which research methods are relevant to that particular research study (Myers, 1997). Two major established, philosophical worldviews inform research studies: positivism and interpretivism (Denzin & Lincoln, 1998)**.**Positivism assumes that reality is objective, and universal truths about reality can be known. Interpretivism subscribes to the view that social reality is subjective, socially constructed and co-constructed, and rejects the belief that truth is singular

and can be objectively measured independently of the investigator (Denzin & Lincoln, 1998).

For this research study, interpretivism is the philosophical stance that relates best to the underlying epistemology. The rationale for choosing interpretivism in this study contains the following elements:

- The researcher gathers data from a small sample of participants with the view to understanding the topic/subject that is being researched (Erickson, 1985).
- The researcher interacts with the participants to explore what is being researched to get a deeper insight on the topic as a whole. Interpretivist researchers do not view their interpretations as beyond question (Neuman, 2000).
- The approach centres on individual people (teachers in this case) and how they interact with ICTs in their teaching (Cohen et al., 1996).

Following Erickson's (1985) interpretation of interpretive research, the researcher's objective was to investigate the extent to which the teachers trained at the Sci-Bono Discovery Centre use ICT in their teaching activities. As noted by Neuman (2000), the researcher used quantitative and qualitative research tools to interact with the participants to explore and get a deeper insight, of the topic at hand.

3.3 RESEARCH DESIGN

A research design is a blueprint for any research project where the researcher outlines the strategy of how the study will be conducted (Ngulube & Ngulube, 2015).

This research study used a survey research design approach, which Muijs (2010) describes as a flexible approach, where the research design is determined by the research questions rather than by any predetermined epistemological position. A survey research design is a measurement process that involves asking questions from a small or large number of respondents to be representative of a larger number of people (Alford, 2011).

The word survey means "to look or to see over or beyond" the superficial observation (Leedy, 1989:141). A survey design is also known as a descriptive survey. The word

descriptive gives insight into the method (Leedy, 1989). A descriptive survey "describes and interprets what is" (Lang & Heiss, 1994:79). A survey design deals with the present through the analysis of data collected using various tools such as questionnaires and interviews (Lang & Heiss, 1994).Using this strategy has the following advantages:

- It is a common approach used with more or less sophistication in many areas of human activity (Leedy, 1989).
- Within this approach, either qualitative or quantitative components can predominate or both can have equal status (Jick, 1979).
- May be used to collect basic information on a problem or to update information on a particular topic (Lang & Heiss, 1994).
- Provide quick, inexpensive, efficient, and accurate means of assessing information about the population (Zikmund, 1994).

However, it may also have disadvantages:

- Data are particularly susceptible to distortion and the influence of bias (Leedy, 1989).
- Questions may be poorly phrased and results misinterpreted (Zikmund, 1994).

This researcher is of the view that a survey research design is relevant to this study as it allows for the use of quantitative and qualitative data collection techniques (Lang & Heiss, 1994). The approach also allows the researcher to interact directly with the participants and further probe what did not come out clearly in the survey responses during the interviews. These gathered data are critical in answering the underlying research questions.

3.4 RESEARCH METHODS

Myers (1997:6) states that "the choice of research method influences how the researcher collects data". As previously stated, the researcher used a survey research design that uses a multi-methods approach that allows for usage of both questionnaires and interviews. Jick (1979) refers to this approach as triangulation, where combinations of methodologies are used in the study of the same phenomenon.

According to Leedy (1989:142), “a commonplace instrument for observing data beyond the physical reach of the observer is the *questionnaire*” (italics in original). Creswell (2005) states that a large amount of information can be collected in a short period using a questionnaire to describe the attitudes, opinions, behaviours and characteristics of a targeted population. Leedy (1989) outlined several practical guidelines when employing a questionnaire as a tool in survey research:

- The language must be unmistakably clear.
- Questionnaires should be designed to fulfil a specific research objective.
- The participants should be informed about the background of the study.
- Written consent should be obtained from the participants.

Lang and Heiss (1994) identified the following liabilities associated with the questionnaire:

- The researcher cannot validate the authenticity of the feedback, as it may be difficult to check on the reliability of the responses.
- Questionnaires that were filled out incorrectly or incompletely may require follow-ups or may have to be discarded.
- Questionnaire returns may be low, requiring several follow-ups.

Interviews allow the researcher to engage with research participants individually, face-to-face, in a way that questionnaires or focus groups do not (Atkins & Wallace, 2012). An interview “is the collection of data through direct verbal interaction between individuals” (Lang& Heiss, 1994:111). An interview is the appropriate tool to use when 1) direct face-to-face contact with persons is imperative, 2) immediate responses are desirable; and 3) its use is feasible (Lang & Heiss, 1994). Leedy (1989) proposed several steps for handling the interview successfully. Below are some of the steps that guided this research:

- Set up the interview well in advance.
- Confirm the date immediately in writing.
- Ask for permission to record the interview.

According to Lang and Heiss (1994), the advantages of an interview over other research tools such as a questionnaire are the flexibility to deviate from the set pattern of questions if the need arises and the ability to probe areas of interest. They

further state that the interview permits immediate checking of information and can provide for greater communication between the interviewer and the interviewee. However, some drawbacks of this technique are also noted. They include, among others:

- Costs of travelling to interview participants.
- Time management.
- The problem of the interviewer's bias and subjectivity.

These two data collection methods, questionnaires and interviews, were adopted in this research study so that the questionnaires informed the interviews. This multi-method survey research design was necessary for this research as it helped the researcher to probe further the feedback obtained through the questionnaires when conducting the interviews. In this research, the questionnaire was developed guided by an extensive review of the literature and consisted of 18 elements, comprising demographic and perceptual data with the last question having an additional 11 elements using a five-point Likert scale ranging from 1= strongly agree to 5= strongly disagree (Appendix F).

The interview agenda consisted of open-ended questions to be conducted face-to-face in a one-on-one setting. The researcher sought permission that was granted from each of the respondents to record the interviews. According to Lang & Heiss (1994), the interviewer can be biased and subjective when conducting interviews. However, this researcher endeavoured to be considerate of the subtle social pressures that the respondents might have been experiencing and allowed them to express themselves freely by trying to make them feel at ease.

3.5 SAMPLING

Sampling is the process of selecting *"*a smaller portion, piece, or segment that is representative of a whole" (American Heritage College Dictionary, 1993:1206). According to Leedy (1989), the survey research (descriptive research) method "requires that the researcher selects from the general population a sample population that will be both logical and statistically defensible". He further argues that there are three processes involved in all sampling procedures, which are:

1. Identify the population, analyse its structure and characteristics.
2. Outline a randomisation method and select the sample by the method.
3. Extract data from the sample population.

The two types of sampling schemes are random sampling and non-random sampling. According to Onwuegbuzie and Collins (2007), in mixed method research, the sampling schemes must be designed for both the quantitative and the qualitative research components. This researcher has used a purposive sampling technique, which is a type of a non-random sampling scheme. In a purposive sampling technique, the researcher chooses the sample based on whom they think would be appropriate for the study (Tongco, 2007). This is used primarily when there are a limited number of people that have expertise in the area being researched (Creswell, 2005). The purposive sampling method also called judgemental sampling, "is most effective when one needs to study a certain cultural domain with experts within and may also be used with both qualitative and quantitative research techniques" (Tongco, 2007:147).

The researcher believed that working with a limited number of participants; the purposive sampling technique was most suitable to achieve the objectives of this research study. As indicated above in chapter 1, the specific focus of this research study was the teachers trained in 2012 at the Sci-Bono Discovery Centre who are teaching mathematics and physical science subjects at secondary schools.

The Sci-Bono Discovery Centre works in collaboration with the Gauteng DoE to provide the training to the teachers. The objective of the training programme is to provide mathematics, science, technology and computer training for all teachers Grade R - 12 that focus on content mastery, assessment, and lesson plan delivery (The eLearning Directorate, GDE, 2011). The Teacher Development Unit (TDU) within the Sci-Bono Discovery Centre, trained the mathematics and physical science teachers in 2012, who then returned to their respective schools. The researcher explored how the training has influenced their teaching behaviour and experiences at their schools. Onwuegbuzie and Collins (2007:282) noted that "there are times when it is appropriate to use small samples in quantitative research, while there are occasions when it is justified to use large samples in qualitative research". The

sample size of the participants was influenced by the fact that the teachers trained in 2013 were largely from primary schools and did not teach mathematics and/or physical science subjects. Therefore, the sample size of the participants was only taken from the teachers that were trained in 2012 influenced by the practical constraints such as the number of trained participants meeting the criteria.

3.6 DATA COLLECTION

In a research study, data gathering is critical as the data is meant to contribute to a better understanding of what is being studied (Tongco, 2007). In some of the mixed methods research studies, quantitative data collection (such as the use of questionnaires), and analysis represent the first phase, whereas the qualitative data collection (such as the use of interviews) and analysis represent the second phase (Onwuegbuzie & Collins, 2007). Thus, the data collection process was categorised into two phases. The first phase involved the collection of the quantitative data using a questionnaire, which involved the piloting of the questionnaire with a selected number of teachers who did not form part of the actual study. The second phase involved one-on-one interviews with the selected number of participants.

After obtaining an ethical clearance (Appendix A) from a UNISA ethics committee, the researcher requested approval from the GDE to survey and interview participants (Appendix C). The participants were from 16 secondary schools that belong to the Johannesburg North and Johannesburg East districts. Before each participant was surveyed or interviewed, they received the information sheet (Appendix D) containing background information about this research study and signed a printed version of an informed consent letter (Appendix E).

- Piloting the questionnaire: Initially, an attempt to pilot the questionnaire with six participants that were randomly selected from the list obtained from the Sci-Bono Discovery Centre proved unsuccessful as only two out of the six participants responded. Other participants gave reasons such as being unable to print and scan the questionnaires due to high costs of using an internet cafe; some stated that they do not have access to a computer and/or the internet. After the above process, for the pilot study, the questionnaire in a printed format with the information sheet and the consent letter were delivered in person on behalf of the

researcher to five teachers. The teachers were from a school that forms part of the Johannesburg West district, which was not part of the research study. Four of the five teachers who completed the piloted questionnaire teach mathematics, and only one teaches physical science. Based on the feedback given, the results did not warrant the need to refine the survey questionnaire as all the questions were collecting the anticipated type of data.

- Surveys: A questionnaire with closed-ended questions was hand-delivered to each participant to collect quantitative data, and 30 participants were surveyed. A suitable date and time were arranged with each participant, and all of the 16 schools where the participants were based were visited to get an effective response rate. Completed questionnaires were collected and captured in Microsoft Excel.
- Interviews: After the completion of the survey process, interviews were scheduled. Due to the large number of participants that were surveyed, the researcher chose to interview only 19 participants. The sample size was selected as part of the non-probability sampling scheme, the objective of which is not to generalise to a population but to obtain insights into a phenomenon (Onwuegbuzie & Collins, 2007). However, only 12 participants were available for the interviews. An arrangement that included a suitable date and time was made with each participant, and the researcher visited him or her on site at the school to conduct the interview. Before the start of each interview, each participant was made aware of his/her right to choose not to participate in the interview. A printed version of the information sheet was issued to each participant, and the participant signed the informed consent letter. The interviews were conducted in a one-on-one setting with open-ended questions that were based on what came out of the surveys. An audio recording device was used to record the interviews, which were later transcribed using the service of a third party that provides transcription services.

3.7 DATA ANALYSIS

According to Remenyi (2013), data analysis is about closely evaluating the collected data to examine its nature and content and should be conducted with a question in mind. He further states that a competent data analysis process results in an in-depth

understanding of the collected data, which may form the basis of interpretation and subsequent theories. However, data do not always come in a proper format ready to be analysed.

3.7.1 Quantitative data analysis

To explore the use of ICT in teaching and learning, quantitative data were collected using a survey questionnaire and analysed using simple descriptive data analysis techniques. The collected data were recorded on a Microsoft Excel spreadsheet with each participant's feedback captured in a row under the relevant column headings. The researcher then used features such as descriptive statistics to draw statistical information that was categorised into *types of computer facilities*, *years of teaching experience*, *use of computer facilities* and many other categories that are discussed in detail in the next chapter, Results. The process of analysing the quantitative data assisted the researcher when preparing to collect qualitative data. During the preparation of the interview questions, categories such as the *uses of computer facilities* were further probed when conducting the interviews.

3.7.2 Qualitative data analysis

Qualitative data analysis looks for meaning from any data, including that which may appear to be quantitative data, without using statistical techniques (Remenyi, 2013). Since data does not necessarily present itself in a format that is ready for analysis, transcripts were created from the interview recordings with the help of a professional company that provides transcription services. The interviews were transcribed into a Microsoft Word document with each interview translating into no less than seven pages. A certificate of veracity was supplied for each transcript of the interview recording, and the third party proofread them. However, the participants were not requested to confirm whether the issues discussed have been written up accurately due to time and availability constraints.

According to Ngulube and Ngulube (2015), in the qualitative data analysis process, raw data must be transformed by searching, evaluating, recognising, coding, mapping, exploring and describing patterns, trends, themes and categories to interpret them and provide the underlying meanings. The transcribed information

was analysed using a thematic content analysis technique. Harding (2013:139) argues that qualitative researchers must note that “all forms of qualitative data analysis involve interpretation and the researcher must always acknowledge the possibility that alternative interpretations are possible”.

Thematic content analysis techniques are a process of identifying concepts and themes in the feedback given by participants of a study and counting the number of occurrences in a tabulated form and then comparing and contrasting them (Hsieh & Shannon, 2005). Bardin (2011) defines content analysis as a set of analytical techniques (syntactic, lexical and thematic) that employ systematic and objective procedures to describe the message contents, using qualitative or quantitative indicators that allow knowledge to be inferred. He further states that content analysis involves describing content based on themes comprised of three stages, namely, pre-analysis, exploration, and treatment and interpretation.

The frequency of concepts and themes are considered central to the technique and desired information is extracted from a body of material (Remenyi, 2013). Thematic content analysis techniques can be applied in qualitative, quantitative, and sometimes mixed modes of research. Nevertheless, faulty definitions of categories and non-mutually exclusive and exhaustive categories are the two fatal flaws that can be encountered when using this method (Stemler, 2001). The material to be analysed can be in written or oral form, a monologue, or dialogue (Remenyi, 2013).

The coding approach used during the thematic content analysis process is the *In Vivo coding* approach in which the themes/categories are taken from what the participants raised during the interview. According to Saldana (2009), this approach is also referred to as data-driven or open coding approach where the categories (themes) emerge from the material to be analysed. He further states that in the *In Vivo coding* approach, concepts and themes are identified and counted, and the occurrences are tabulated, compared, and contrasted. This researcher carefully read the interview transcripts and at times listened to the interview recordings to look for key words that deliver meaning and context to the passage being analysed, which then helped in establishing categories (themes). The systematic process that was followed when analysing the qualitative data is described below:

- **Step 1**: The first cycle of coding in which several themes/concepts emerged from the data in the transcripts of the interviews. The portion of data to be coded can range from a single word to a full sentence or an entire page (Saldana, 2009).
- **Step 2**: When searching for patterns in coded data to categorise them, the focus should also be given to the commonalities within the data not just because they are exactly alike or much alike, even if that commonality consists of differences (Saldana, 2009). In the second cycle of coding, the coded themes/concepts, which came from the portions or passages of transcribed interview data, were merged with other common themes/concepts to establish categories. In this case, issues that were raised by the respondents were grouped into seven core categories.
- **Step 3**: According to Saldana (2009:4) "a code can sometimes summarise or condense data, not simply reduce it". Codes were developed and assigned to all categories of data, and the overall data were presented using a table with the following headings: concept/theme, code, and frequency of occurrences and percentage.
- **Step 4**: The portions or passages of text were counted in each of the interview transcripts to establish the frequency/number of occurrences. To get the percentage, each frequency was divided by the total number of frequencies and multiplied by one hundred.
- **Step 5**: According to Remenyi (2013), the establishment of the codes directs and focuses the research and the association of different parts of the text with particular codes and leads to the possible findings. Based on the above process (steps 1 to 4), the results were drafted and presented based on the frequency of occurrences and the percentages.

3.8 RESEARCH ETHICS

Ethics in research protects everyone from harmful or adverse consequences (Cooper & Schindler, 2003). Driscoll (2011) identified issues that must be considered when involving human participation in a research study namely: voluntary participation, confidentiality, and anonymity and researcher bias. The need to adhere to the principles of ethical research is vital, and this research study has been granted ethical clearance by a UNISA ethics committee (Appendix A).

The GDE granted written approval for the teachers to participate in the study (Appendix C). Participants signed an informed consent form (Appendix E) and participated voluntarily. They were also informed about their right to withdraw from the study, and they were given an assurance of anonymity and confidentiality. Zikmund (1994) outlined the respondent's rights and obligations that guide this research:

- The obligation to be truthful. Honest cooperation is the main obligation of the respondent.
- Privacy. All the participants were assured of their anonymity and confidentiality.
- The right to be informed. Participants were given an information sheet (Appendix D) that contained the background of the research study.

3.9 CHAPTER SUMMARY

This chapter presented a discussion of the research methodology that was followed in this research study. Interpretivism was used as the underlying philosophical framework for this research study. A survey research design that uses mixed methods, namely questionnaires and interviews, was used when collecting data. The surveys were done with 30 participants, and 12 of them were subsequently interviewed. The collected data were analysed in two stages: first, the surveys were analysed using descriptive analysis techniques, and then transcribed interviews were analysed using thematic content analysis techniques. The chapter concluded with a discussion on ethical research; identified the ethical issues to be considered in a research study that involves human participation, and further highlighted the rights and obligations of the participants in a research study. The next chapter presents the research findings that are based on the analysis of both quantitative and qualitative data sources.

CHAPTER 4: RESULTS

4.1 INTRODUCTION

Chapter 3, Research Methodology, discussed the interpretive philosophical grounding that guided this research study, the survey research design that used a multi-method approach for data collection and the analytical tools that were used namely descriptive analysis and thematic content analysis techniques. The chapter concluded with a discussion of the ethical considerations in research studies that involve human participation and further outlined how ethical clearance was obtained for this particular research study. The purpose of this chapter is to present the findings of this research study.

This chapter presents the results of the analysed data that was collected using a questionnaire with closed-ended questions and the one-on-one interviews. These results include the quantitative as well as the qualitative data components collected during the fieldwork. Table 4.1 outlines the demographics of the 30 participants that were involved in this study regarding the years of teaching experience and the subject(s) that they teach.

Table 4.1: Participant demographics

Experience in Years	Mathematics	Physical Science	Both
Less than a year	2		
1-2 years	1	1	1
3-4 years	2		2
5-6 years	3		
More than 6 years	15	2	1
Total	**23**	**3**	**4**

4.2 SURVEY RESULTS

The collected survey data were recorded on a Microsoft Excel sheet, with each field captured under the appropriate column heading in preparation for analysis. The analytical process was performed using simple descriptive data analysis techniques, and the results are presented below using tables and charts.

4.2.1 Question 1: Which of the two subjects are you teaching?

As indicated above in Table 4.1, more mathematics teachers at 77% participated in the survey questionnaire, with participants who teach physical science subject standing at only 10%. The remaining 13% of the participants teach both subjects.

4.2.2 Question 2 and 3: How long have you been teaching mathematics, physical science or both?

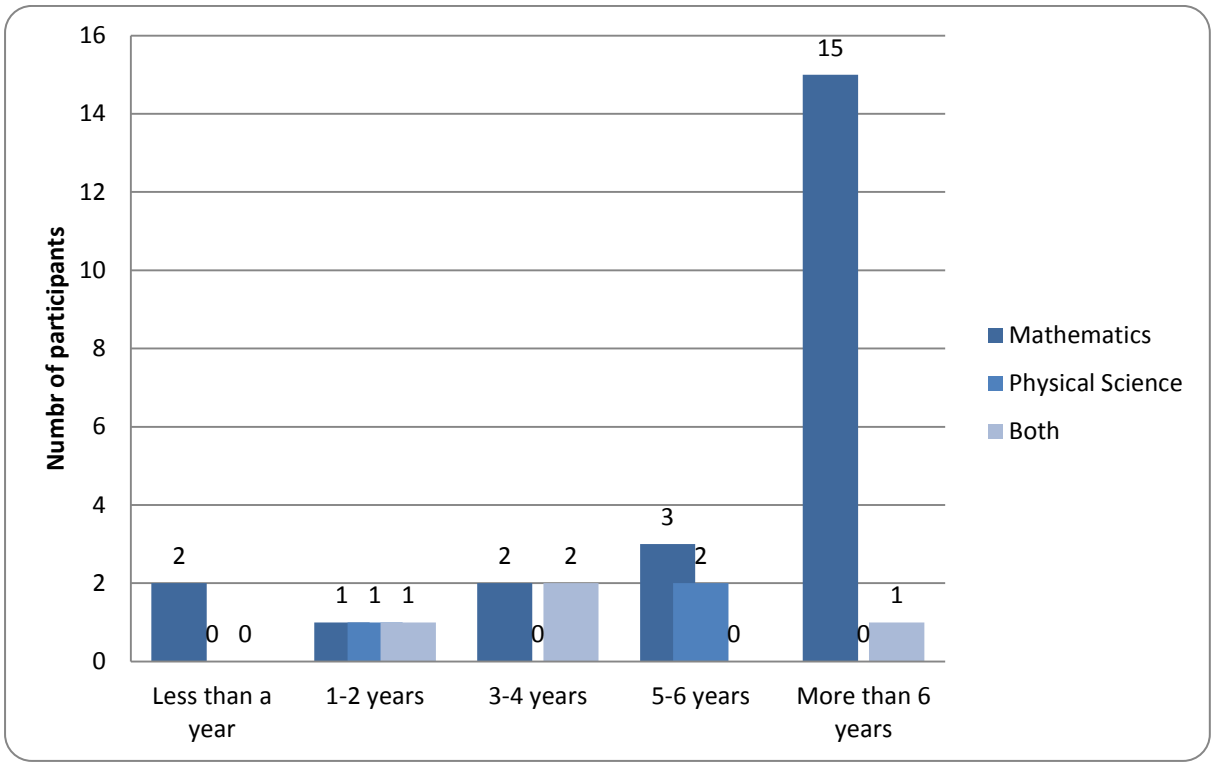

Figure 4.1: Years of teaching experience

The largest numbers of teachers who have teaching experience of more than six years, as shown in Figure 4.1, teach mathematics. This indicates that while many of the participating teachers have been in the profession for six years or longer, some teachers had between one and six years teaching experience, which balanced the numbers to some extent. Three participants taught physical science, with the other four teaching both subjects.

4.2.3 Question 4 and 5: Are there computer facilities at your school? Which of the following computer facilities exist at your school?

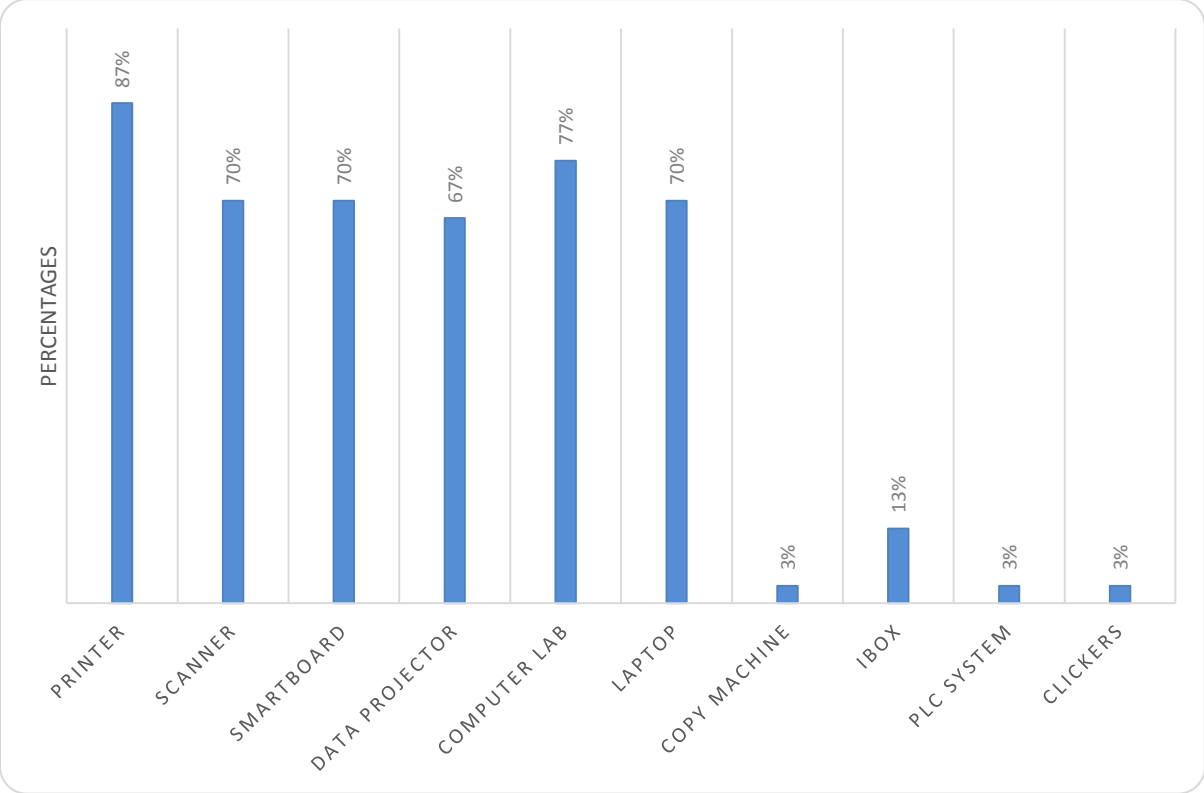

Figure 4.2: Types of computer facilities at schools

Figure 4.2 outlines the range of facilities, which the participants indicated exist at their respective schools. All the surveyed participants have indicated that they have at least one or more of the listed computer facilities at their respective schools as shown in Figure 4.2. The commonly available facilities include printers, scanners, smartboards, data projectors, computer labs, and laptops. However, less than 10% of the participants listed other computer facilities such as the iBox, Plc system, and Clickers without providing full details of what they do. These are described below.

iBox is a tool that is aimed at assisting pupils to improve their school results and is useful for revision because it can record lessons and store them. It also stores presentations, past exam papers, e-learning material, and an electronic dictionary.

Plc system – Professional Learning Communities systems are designed to help increase the capacity of the school to achieve sustainable improvement in the

learning that takes place in the school. Their two objectives are to improve teacher practice and improve learner achievement.

The Clickers system is a feature of the *eInstruction Pulse* that is part of the iBox and allows learners to enter short answers so educators are not only asking true, false or multiple-choice questions.

Although over 80% of the participants indicated that they have printers, followed by more than 70% that have computer labs and just below 70% that have scanners, smartboards, data projectors and laptops, some participants have indicated that in certain instances, these computer resources have to be shared among teachers and learners.

4.2.4 Question 6: Do you have access to computer facilities at your school?

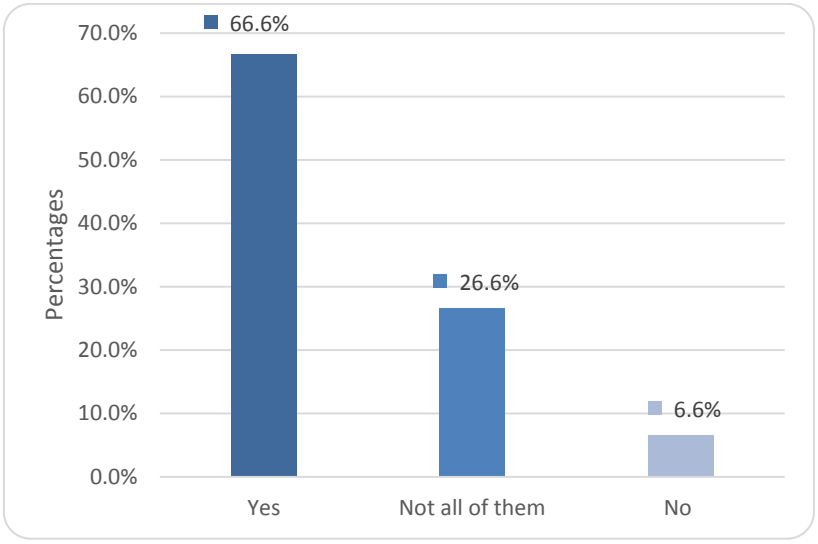

Figure 4.3: Access to computer facilities

Although a large number of participants, at above 60%, indicated that they have access to the computer facilities as shown in Figure 4.3, they are at times compelled to share them where there is only one laptop per department. This indicates that facilities are not necessarily readily available when teachers want to use them. Only 26.6% of the participants indicated that they have access but not to all of the computer facilities at their school with less than 10% stating that they do not have

access to the facilities including laptops, smartboards, computer lab, scanners, printers, and data projectors.

4.2.5 Question 7: How often do you use the computer facilities at your school?

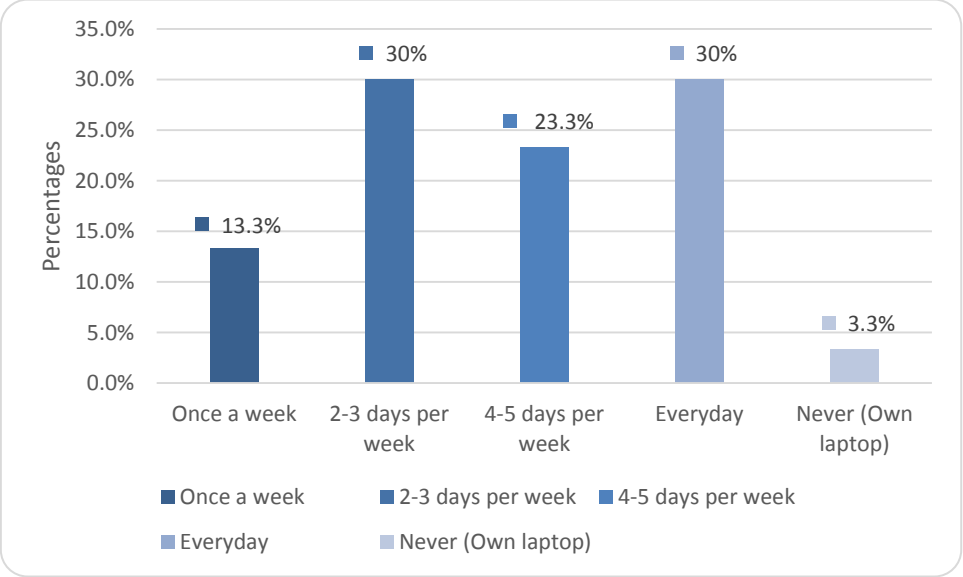

Figure 4.4: Computer facilities usage per week

It is clear from Figure 4.4 that there is a spread across the week usage of computer facilities at schools. The one teacher who claimed to have never used the facilities gave as his/her reason that s/he has a laptop, and the school only provides the data projector. However, these instances of computer facilities usages spread across the week are not conclusive because participants were not asked to mention the specifics as to what tasks are being performed and for how long. Furthermore, participants were also not asked whether they wanted to use the computer facilities more but could not or whether the access was sufficient.

4.2.6 Question 8: Usage of the computer facilities?

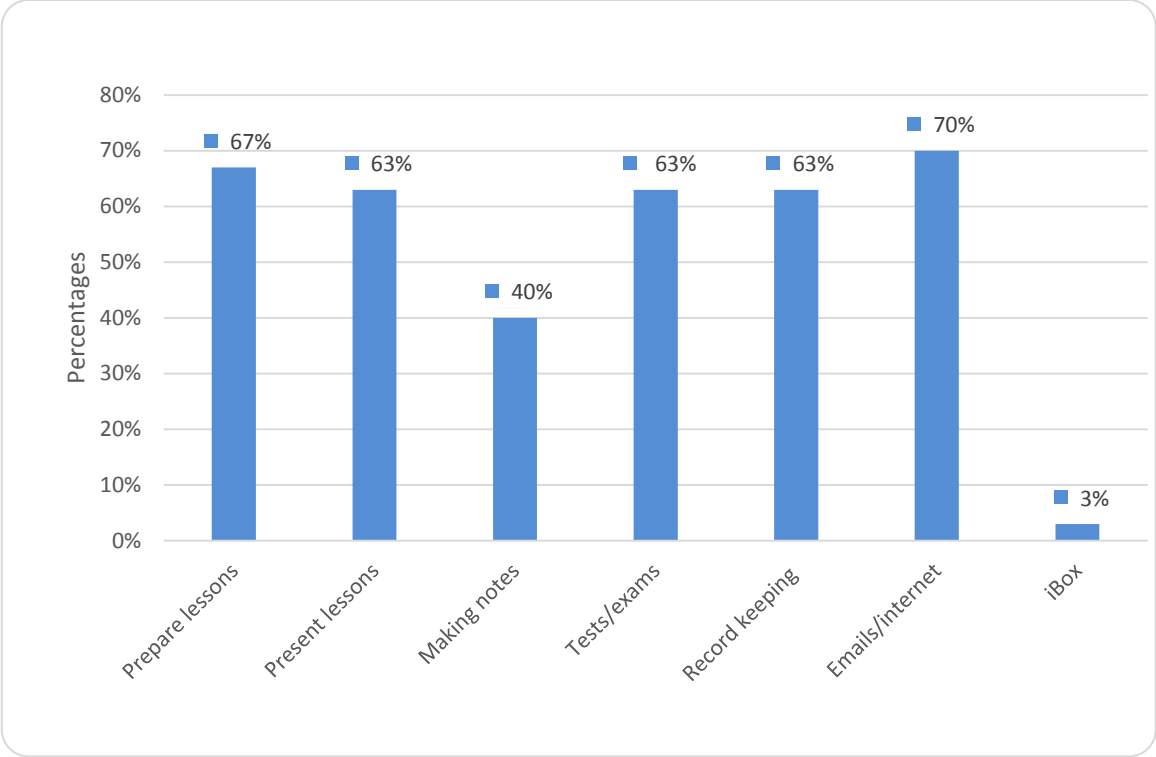

Figure 4.5: Use of computer facilities

The computer facilities at schools, as shown is Figure 4.5, are mainly used for lesson preparation, lesson presentation, preparation of tests/exams, keeping records and for emails/internet. They are less commonly used for making notes and assessments using iBox. These percentages show that teachers are to some extent using ICT in their teaching activities, but this will be discussed further in the next chapter, Discussion, for both survey and interview findings.

4.2.7 Question 9: Which of the following Microsoft Office tools do you regularly use to prepare lessons?

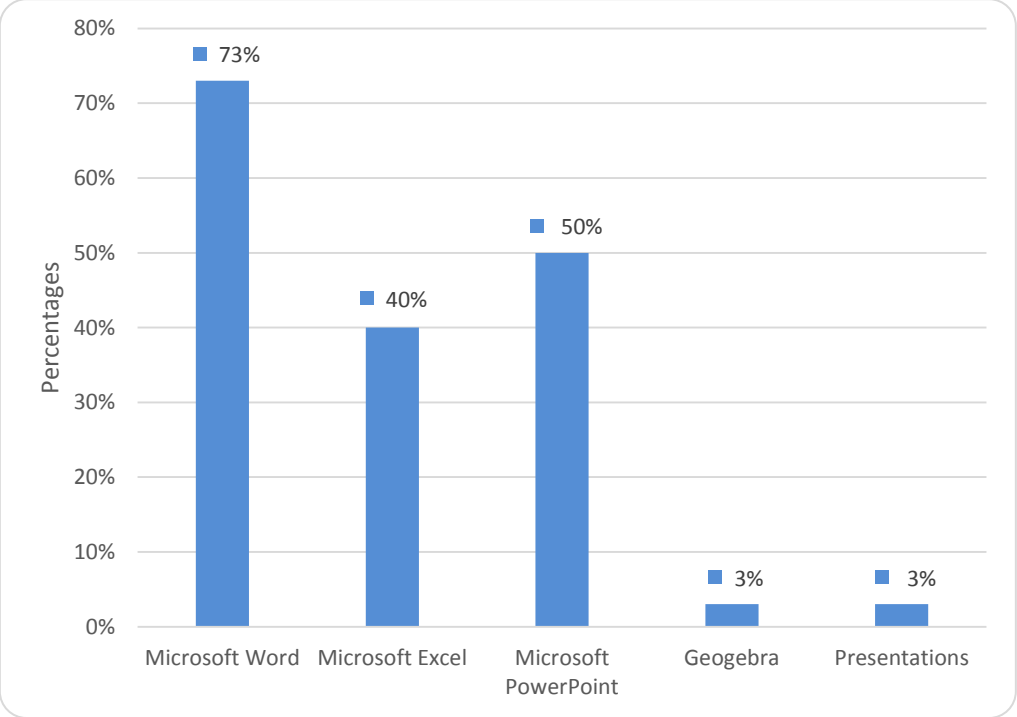

Figure 4.6: Tools used for preparing lessons

A significant number of participants use Microsoft Word when preparing lessons as shown in Figure 4.6. One participant listed a tool called Geogebra, which is a pre-installed application on the smartboards that is designed to help learners with mathematics. The next chapter, Discussion, addresses the tools commonly used for teaching, and the challenges that teachers encounter when using those tools.

4.2.8 Question 10: Which of the following Microsoft Office tools do you regularly use to present lessons?

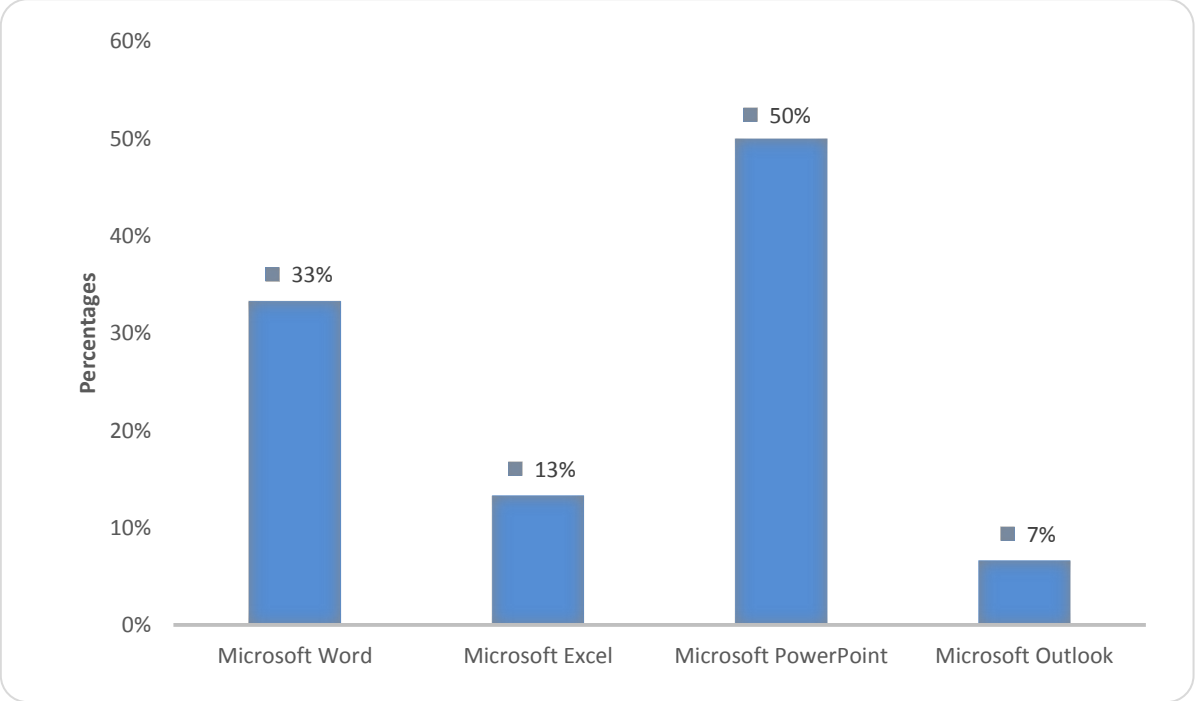

Figure 4.7: Tools used for presenting lessons

From Figure 4.7 it is clear that the most notable tool that is used for presenting lessons is PowerPoint. However, for mathematics and physical science, it is also possible to use Microsoft Word or even Excel specifically when teaching mathematics, because it has features to perform formulae and calculations. A few participants selected Microsoft Outlook; however, it was not clear how it was used in presenting lessons.

4.2.9 Question 11: Which of the following Microsoft Office tools do you regularly use to prepare tests/exams?

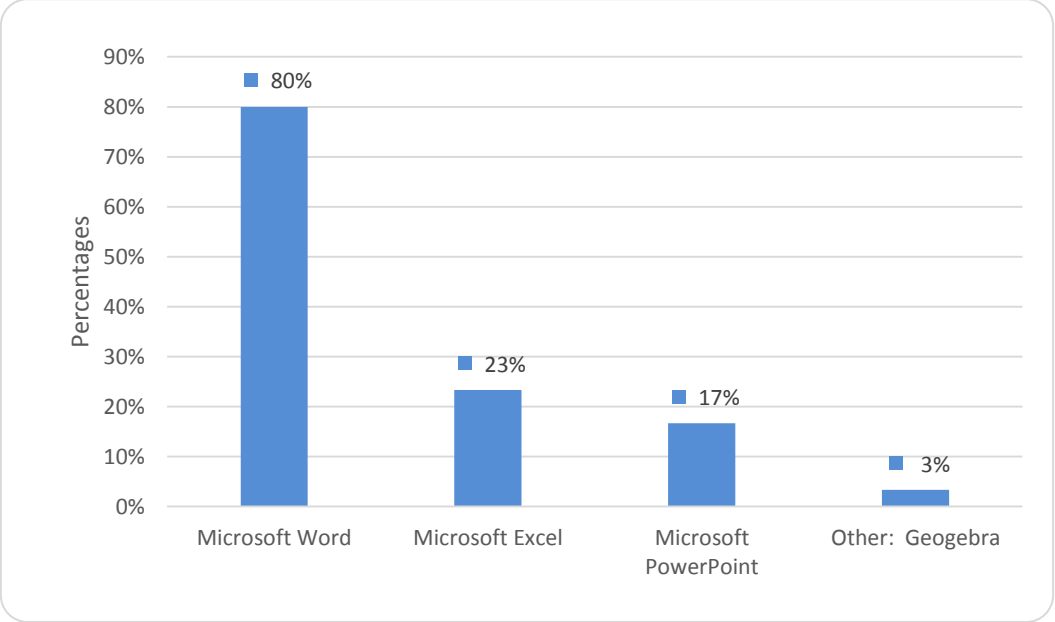

Figure 4.8: Tools used for preparing tests/exams

Figure 4.8 shows that the preferred tool when preparing exams or tests is Microsoft Word, whereas the other Office application tools were rarely used for this purpose. This is what could be expected as Microsoft Word contains many features, including importing external files such diagrams and pictures, for use in assessments. Although Microsoft Excel and Microsoft PowerPoint could still be used for preparing exams or tests, they only constitute a small percentage, which is just below 20%, and this may be because they will only be used for small sections of the exams or tests.

4.2.10 Question 12: Which of the following Microsoft Office tools do you regularly use for record keeping?

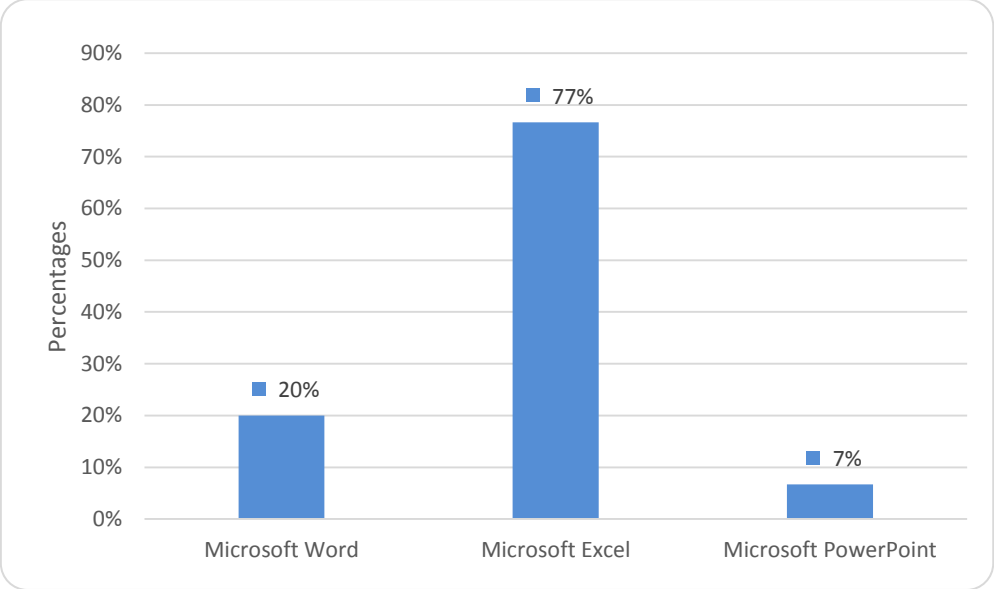

Figure 4.9: Tools used for record keeping

Figure 4.9 shows that the most popular tool for record keeping, such as maintaining class registers and mark sheets, is Microsoft Excel (at above 70%). The next chapter, Discussion, will provide further details of how participants perform this activity. Some participants stated that they use Microsoft Word, which may be attributed to its broad features. Furthermore, a small number highlighted the use Microsoft PowerPoint that also has certain features to create tables, which in turn can be used to record information.

4.2.11 Question 13: Rate your Microsoft Office tools skills level before the training.

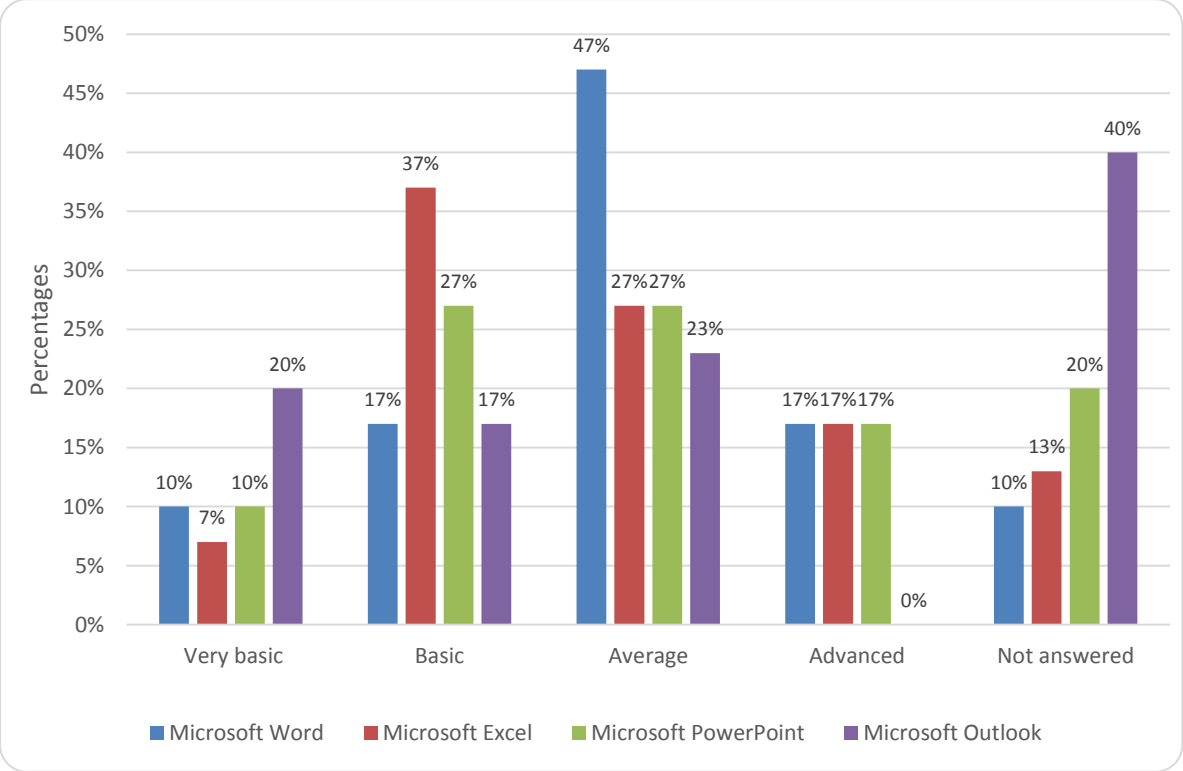

Figure 4.10: Microsoft Office skills before training

Figure 4.10 presents the participants' rating of their Microsoft Office skills levels before attending the training. The participants rated Microsoft Word highly. However, it is clear that the participants were generally not highly skilled in using Microsoft tools before attending the training programme. Some participants chose not to provide answers to this question, and they instead left it blank. The highest abstentions were in Microsoft Outlook and Microsoft PowerPoint. This factor, attributed to the participant not properly understanding the question, meant that the statistics could not be conclusive due to the lack of feedback.

4.2.12 Question 14: Rate your Microsoft Office tools skills level after the training.

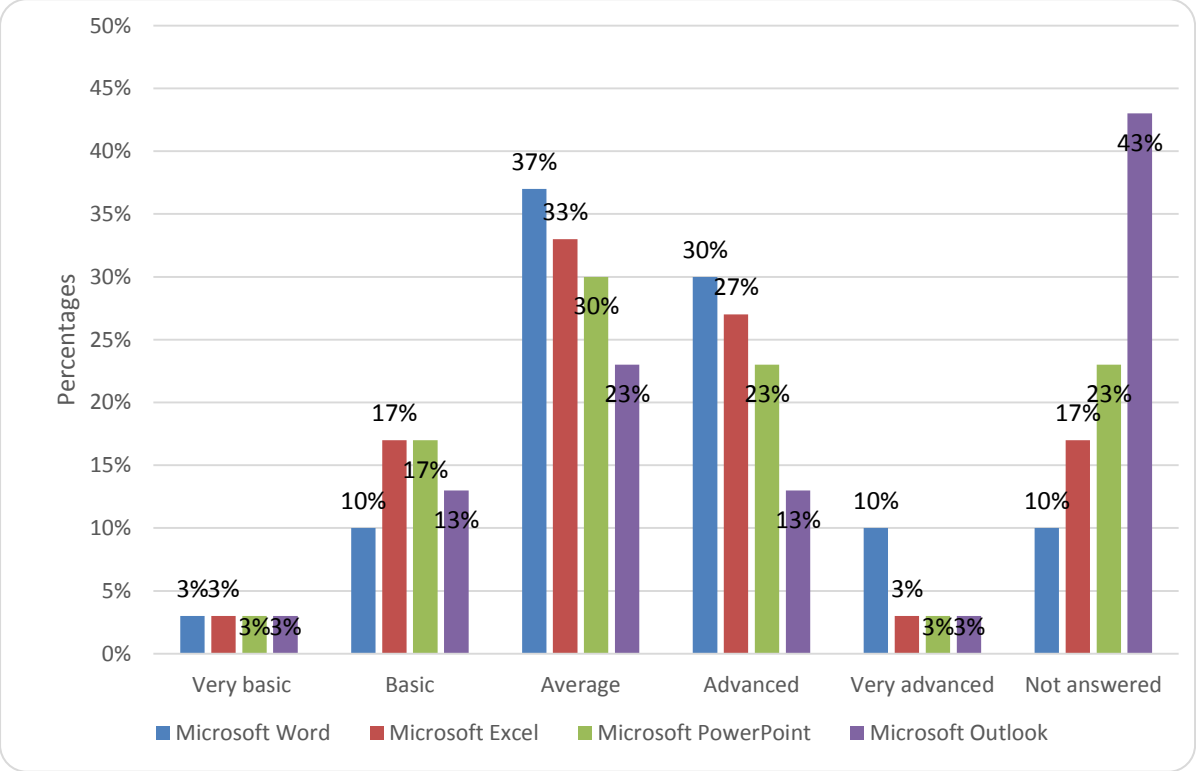

Figure4.11: Microsoft Office skills after the training

As seen in Figure 4.11, the number of participants whose skills levels were basic before attending the training programme decreased from 20%(Figure 4.10) to 3%(Figure 4.11) after attending the training. Participants whose skills levels were basic also decreased from just above 35% to 17% (see Figure 4.10). This shows that participants felt that their skills levels had improved after attending the training. Regarding the participants whose skills levels were on average and advanced the percentages shows a slight decrease from 45% (see Figure 4.10) to just over 35%. This can be attributed to the fact that participants felt that they were at an advanced skills level, which went from a maximum of 17% (see Figure 4.10) on all tools to a maximum of 30% with MSWord being the highest. Additionally, some participants improved from the advanced skills level to the very advanced skills level. This shows that the training has influenced the participants positively, but because of the number of participants who did not answer the question, the statistics are not conclusive.

4.2.13 Question 15: What are your thoughts about the purpose of the training?

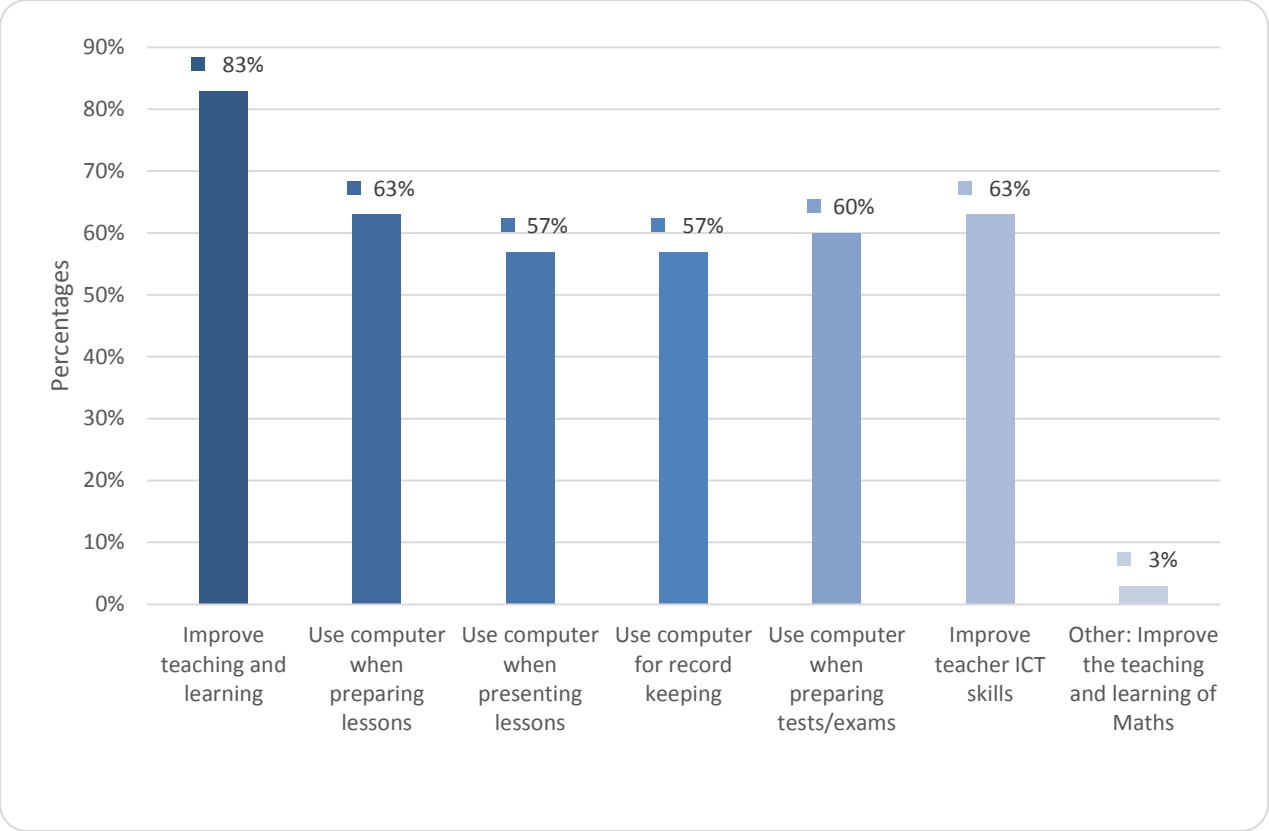

Figure 4.12: Participants views about the purpose of the training

In Figure 4.12, the results show that the participants understood what the training was meant to do, with more than 80% stating that the training was about improving teaching and learning. Based on the feedback, it can be concluded that the participants were well informed about the training programme and they all understood that the training was meant to equip them with computer skills for preparing lessons, presenting lessons, record keeping, preparing tests/exams, and improving their ICT skills. Therefore, a significant number of participants understood that the training outcomes were supposed to have capacitated them to be able to utilise ICT in their teaching activities.

4.2.14 Question 16: What did you hope to gain from the training?

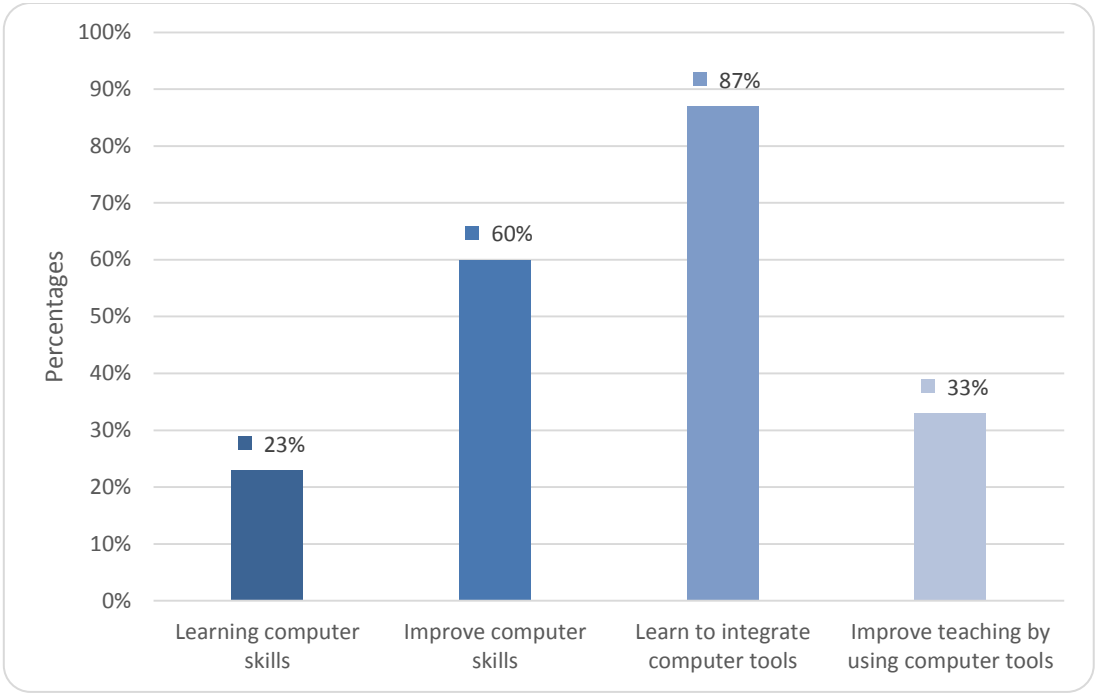

Figure 4.13: Teachers expectation of the training

As shown in Figure 4.13, most participants had hoped that the training would empower them to use computer tools in their teaching activities. These views are in line with the objectives of the GDE and Sci-Bono Discovery Centre. The general view of all the participants, based on the feedback given to this question, is a positive one. However, this question was probed further during the interviews to establish whether their expectation was met and will be further discussed in the next section that discusses the interview results.

4.2.15 Question 17: What is your view about what you learnt at the training?

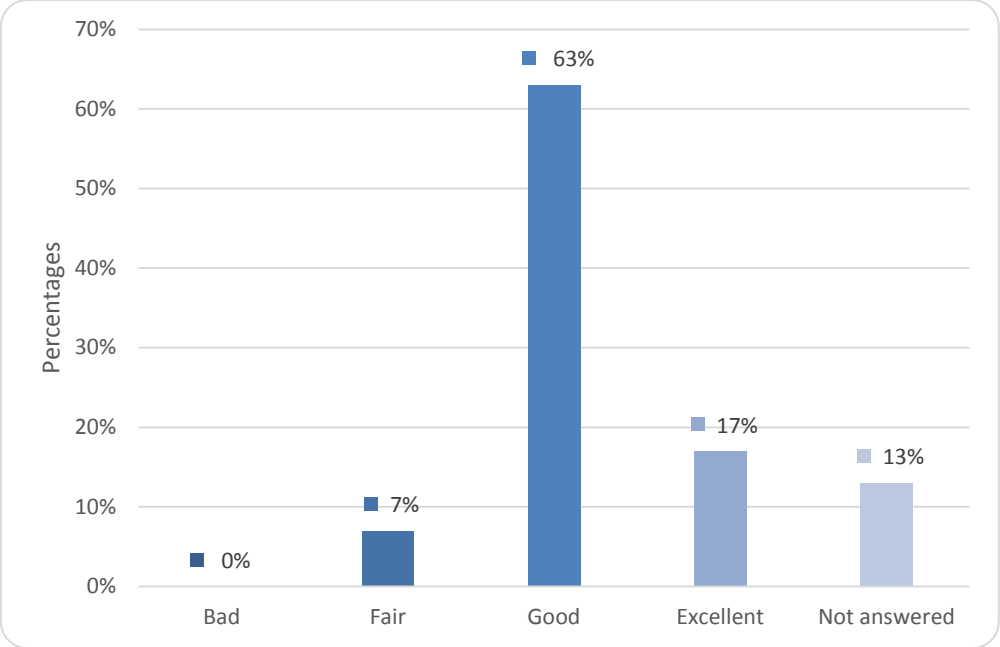

Figure 4.14: Rate the training

Looking at Figure 4.14, the overwhelming view for most of the participants was that the training was good at 63% with an additional 17% saying the training was in fact excellent. This is a positive view, as no participant stated that the training was bad. However, 13% did not answer this question. Judging by this feedback for question 17, one can safely conclude that a large number of the participants that attended the training were happy about the outcomes of the training and what they have learnt.

4.2.16 Question 18: This question consisted of 11 elements and used a five-point Likert scale

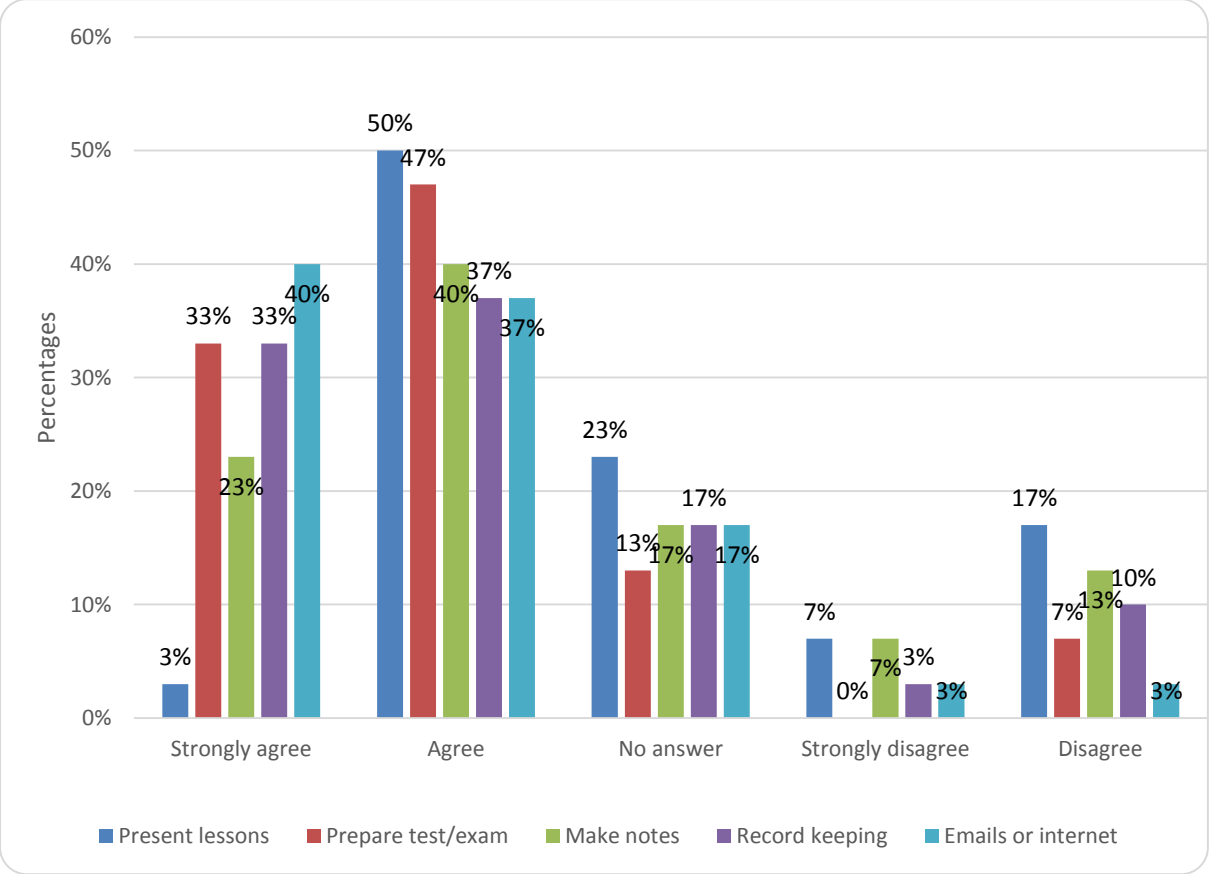

Figure 4.15: Computer tools usage

Figure 4.15 shows the feedback for the questions that were asked about the participants' use of computer tools. These questions were asked deliberately to determine whether the participants were using their newly-acquired ICT skill in their teaching activities. The responses pointed to the reasonable levels of use in terms of percentages for the lesson preparation, preparing test/exam, record keeping and emails or internet. The usage levels were fairly high as most participant agreed to be using the computer tools for these activities. Only less than 20% of the participants disagreed, and some chose the *No answer* option, which might point to the fact that they are not using ICT for any of the activities that were listed. However, the overall feedback showed a positive indication that the participants were utilising their newly-acquired ICT skills in their teaching activities.

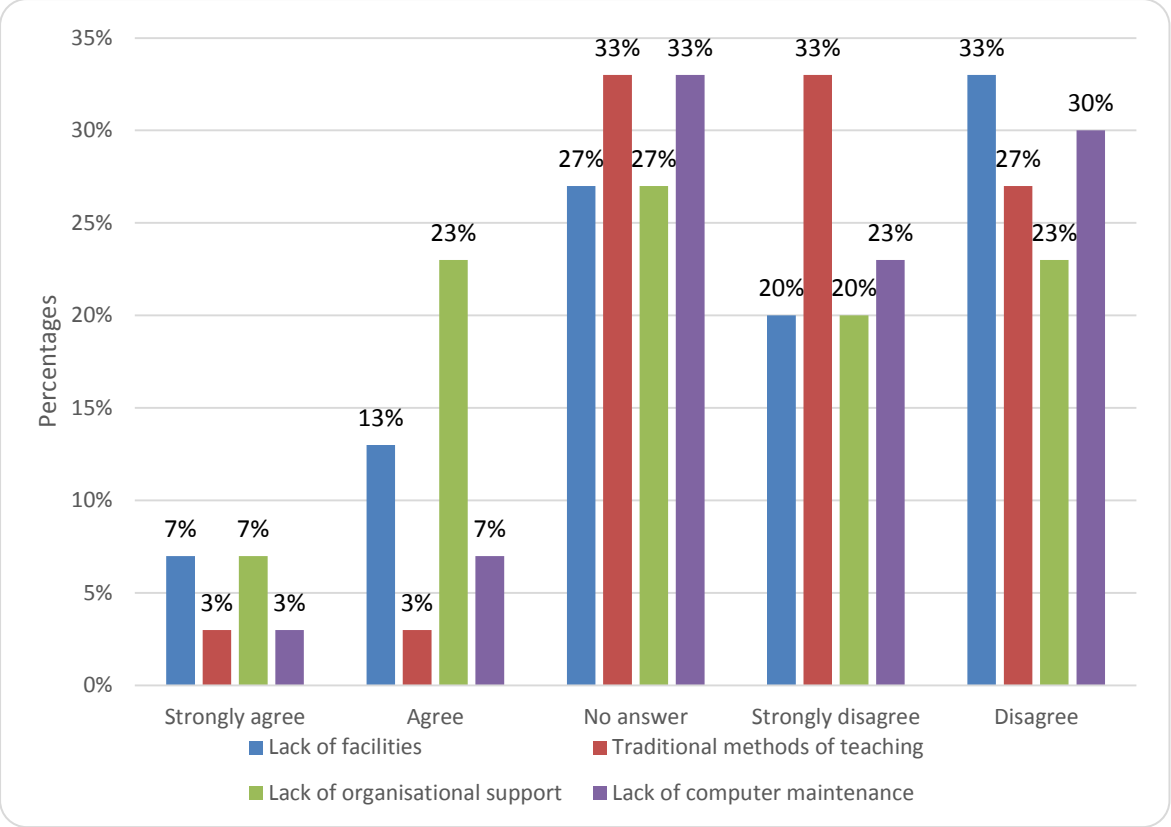

Figure 4.16: Lack of computer tools usage

Figure 4.16 presents the answers to questions, which were asked about the participants' perceived contributing factors to their lack of using ICT when teaching. The purpose of this question was to establish whether the listed barriers were among some of the contributing factors. The responses pointed to the lack of organisational support as the most contributing factor while other factors such as the lack of technical support and lack of computer facilities were also highlighted like the other contributing factors. However, some participants chose the no answer option, which might also indicate that what they perceived to be the obstacle(s) to their lack of using ICT when teaching was not on the list.

4.3 SUMMARY OF THE SURVEY RESULTS

- The survey questionnaire data were obtained from 30 participants, a significant number of them were teaching mathematics, and others were teaching physical science with a few teaching both subjects. The feedback painted a picture in which some teachers noted that they use ICT in their teaching activities, and they noted the presence of computer facilities at some of the schools.

- Although feedback collected has pointed to the availability of computer facilities at some of the schools, the weekly usage levels were very low. The low levels may be attributed to the fact that the computer facilities may not be readily available when required for use. The usage of computers, printers, and scanners at the schools will be explored further in the section that presents the interview results.
- There was a clear indication that some participants use the computer facilities for carrying out the relevant teaching activities such as preparing lessons, presenting lessons, and recording marks. The results further established that Microsoft application tools are often used for different teaching activities.
- A significant number of participants were of the opinion that their computer skills levels with Microsoft Office applications have improved after attending the training. This is a positive development as it indicates that the participants gained additional skills through the programme.
- Most of the participants were of the opinion that the training programme was of a good quality and some even stated that it was excellent; only a few thought that the training was fair, but none indicated that it was bad, which is a clear indication that the participants were positive about what they learnt in the training.
- In the last question, participants were asked what they use computer tools for, and most of them agreed that they use the computer tools to prepare and present lessons as well as for record keeping and preparing tests/exams. Several obstacles to the use of ICT in their teaching activities were also highlighted which are attributed to the lack of technical support, lack of facilities, resistance to change and inadequate organisational support.

The next section presents the interview results, where some participants noted that despite the training being good, they require it to be provided on an ongoing basis to help them keep up with the new trends in the technological space while others expressed an opinion that they require an advanced form of training. Furthermore, the section will also explore what teachers perceive to be the barriers to using ICT in teaching.

4.4 INTERVIEW RESULTS

Interviews were conducted with 12 participants in a one-on-one setting and were recorded with the interviewer noting down field notes. The data revealed the following overall results.

4.4.1 Summary of interview questions and responses

Table 4.2 presents a summary of the different questions that were asked during the interviews and the responses that were given.

Table 4.2: Summary of interview questions and responses

Question	Responses
What were your expectations of the training?	• 75% of the participants indicated that the training had exceeded their expectations. • 58% stated that the training contributed to improving their computer skills.
Was there anything missing from the training or what would you have liked to see, but was not there?	• 42% thought that the training was basic, less than what they expected and not intensive enough due to time constraints.
What is your view(s) about what you have learnt through the training?	• 75% indicated that they were trained to prepare lessons or a question paper using Microsoft Word. • 83% stated that the training taught them to record marks, typing and preparing mark sheets using Microsoft Excel. • 58% stated that they can present lessons using Microsoft PowerPoint with a projector or connect the laptop to the smart board.
What do you find most challenging about putting the skills you learnt into practice in preparing for, and presenting, lessons?	• 33% identified the sharing of one laptop per department as one issue that they find challenging when it comes to putting their skills into practice.
Do you, and if so, how do you, use Microsoft Office in preparing for, and presenting, your lessons? e.g. Word, Excel and PowerPoint	• 58% indicated that they present lessons using Microsoft PowerPoint with a projector or connect a laptop to the smart board.
Are there any challenges that you encounter when using the computer facilities? What are those challenges?	• 50% indicated that although they do have a computer lab, it is always locked and is shared with the learners.
What do you think can be done to overcome those challenges?	• 25% stated that to overcome challenges government must provide the support required such as enough computer resources at schools. • 58% indicated that the teacher-training programme should be provided continuously on a yearly/ quarterly basis.
What is the minimum level of support that you would feel necessary to encourage you to use ICT in teaching and learning?	• 67% of the participant's views regarding this question were that each teacher/department must have a laptop.

Question	Responses
What do you consider to be barriers or obstacles to the use of ICT in teaching and learning at your school?	More than 90% of the participants identified the following as some of the challenges: • Lack of computer resources • Lack of internet access • Lack of ICT coordinator/technician at schools • Existing facilities not maintained, e.g. smartboards
Is there any improvement in the teaching and learning of your subject when ICT is used? What has improved?	• 75% stated that there is still a lot to learn such as understanding how the smartboards work, saved work gets lost because of viruses, setting up papers, adapt to change, no training manuals, not enough time.

4.4.2 Themes/categories and concepts

Table 4.3 presents the codes that were derived from the participants' responses to the interview questions with six broad themes/categories as well as their respective concepts/subthemes that emerged from the thematic content analysis process. However, it must be noted that different coders may see the issues differently and may not necessarily use the same codes. As indicated in the research methodology chapter, the coding method used was an In Vivo coding process. The codes that are presented in Table 4.3 are a summary of the issues raised during the interview.

Table 4.3: Themes/categories and concepts

Theme/Category	Concepts
Training outcomes	• Good and exceeded expectations • Improved computer skills • Very basic and did not meet expectations
Perform administrative tasks	• Record marks and prepare marksheets • Prepare question papers
Teaching and learning activities	• Lesson presentation • Lesson preparation
Training gaps	• Provide training on an ongoing basis
Challenges/barriers	• Lack of computer facilities • Lack of internet access • Not enough printers, smart boards and overhead projectors • Lack of support • Lack of access to computer lab
Interventions	• Provision of one ICT coordinator per school • One teacher one laptop

4.4.3 Training outcomes

This theme summarises the participants' overall views about the training programme. It encompasses three concepts or subthemes.

- Good and exceeded expectations: This subtheme supports the view that the training provided to the participants was good and exceeded their expectations as attested to by the following comments. When asked whether there was anything missing from the training, P2 noted:

  "I don't think there was anything actually in my opinion, the training exceeded my expectations. I'm satisfied with whatever I got there".

  It was clear from some of the participant's views that they were positive about the training outcomes and their newly-acquired skills as attested to by P3 who noted:

  "My expectations were number one, to make myself aware of the technological advancement so far in mathematics. Number two was to broaden the knowledge of mathematics technology in teaching and learning. Basically, I didn't see anything missing because what I expected was well addressed".

  P6 agrees that the training was good but also highlighted what could be attributed to the challenges that teachers encounter at their respective schools when they need to utilise their newly-acquired skills:

  "With me I can say, well the training it was okay and it was good value. It was empowering because that is what we want as teachers. Then it would be advisable that when they train the teachers they do not just take teachers at random, if a teacher has a laptop or if a teacher has access to a computer then it becomes easier. So, I think that next time if they can look at those things because whatever I learn there I will come back and practice and when I practice it will make my life easier".

  P8 gave a satisfactory account of the training:

  "Everything was there and then, how they interacted. The facilitator was excellent".

- Improved computer skills: This subtheme highlights what some participants viewed as influencing their computer skills in a positive way. P2 stated:

  "Yes, I went there with basics, but now I am very much advanced in so far as the use of ICT is concerned".

  P4 supports the fact of improved computer skills:

  "The training has helped me a lot, and I can say it boosted my confidence in using computer in class as a teaching object."

- Very basic and did not meet expectations: However, some participants pointed out that for them, the training was basic and did not meet their expectations. P5 noted:

  "Yes, intensive training, like intensive training we can do, to be honest. So it should be intensive in a way".

  Other participants had similar opinions:

  "It was a basic computer literacy. I believe the skills that I have already are sufficient for the job that I am doing. But I would like to learn more for the computers. Because I have seen that, there is more to computers than just typing and setting papers. A computer can do more. So I think an advanced training for computers" [P7].

  P1 asserted, *"Actually the training was basic"* and P4 had more expectations, *"I expected more than what I got".*

4.4.4 Perform administrative tasks

This theme outlines participants' overall views about the benefits of the training programme. It encompasses two concepts or subthemes.

- Record marks and prepare marksheets: Some participants noted that the training contributed to enabling them to perform their administrative tasks more effectively:

  "Yes, even recording of marks was there, typing and recording of marks, preparing the mark sheets"[P1]:
  "I use Excel also to keep my record of my mark sheets". [P7].

  P2 is of the similar view:

  "My views are that what I've learnt is very helpful you see. I am no longer doing things manually for instance calculation of marks. I am able to put the formulae on my laptop. I just enter the marks, it calculates, actually I worked the formulae myself. I can say, since the training I'm very literate in as far as the computer is concerned".

  P6 asserted that s/he is able to create his/her own mark sheets and generate statistics of the learners who passed and failed:

"Just to be able to design my own mark sheet instead of going to the office to ask them to do that for me and so that everything is in the system. When we are busy with reports, we find that for this learning area, we also want statistics to see how many learners passed, how many learners failed and then they want the average. With the computer, it becomes easier if you use it, so that is what I was hoping to do".

P9 has derived some benefits from what came out of the training:

"I think the only positive thing is. It has helped me to be more efficient in my record keeping. Because all of our working marksheets have to be computerised. Therefore, that is no longer a problem."

- Prepare question papers: P1 noted, *"We were actually taught how to prepare a question paper like typing".* P6 stated that the training enabled him/her to draft his/her own tests*, "I am able to draft my own tests"*.

4.4.5 Teaching and learning activities

This theme identified the teaching activities which the participants perform using their computer resources. It contains two subthemes.

- Lesson presentation: When it comes to the presentation of their lessons, some participants highlighted the fact that they make use of the computer software tools such as PowerPoint with an overhead projector or by connecting the smartboard to the computer since it has pre-installed Microsoft Office applications. P3 noted:

  "I normally, or in most cases I use PowerPoint and Word".

The use of a smartboard and a projector was highlighted by P2:

"I only use that smartboard together with the projector because if I was using the projector, then I would use this one that has got slides".

Other participants give learners some class activities, P4 stated:

"Number one, I present the lesson through the PowerPoint to learners, and then their response is going to be in the form of a class activity in their workbooks. I will explain the questions on a screen and learners take questions down and give me answers in their workbooks".

In addition, P5 asserted:

"Normally we use PowerPoint in terms of giving the learners some definitions you know in mathematics they have got some definitions".

However, not all responses were positive as P9 stated:

"As far as lesson delivery is concerned, nothing has changed. We are still using the same old archaic methods of teaching".

- Lesson preparation: Regarding the preparation of lesson plans, some of the participants indicated that they make use of Microsoft Word. P3 stated:

  "I use Word when preparing work schedules and daily lesson plans".

  P7 had a similar answer.

  "I mostly use Word to prepare my worksheets".

  P6 noted that s/he encounters challenges when preparing geometry lesson plans because s/he has to draw symbols.

  "I find that maybe the circles are incorrect if you teach geometry the circles have to be accurate so that learners see what is happening with your diagram. Since in geometry, if you find that you are not able to draw that circle and everything that is in that circle then it becomes a problem. But that is how I use it".

4.4.5 Training gaps

This theme came about when the participants were asked about what was lacking in training, and they highlighted the issue of time by stating that there was not enough time regarding the duration of the training, while others were of the view that there should be an advanced training programme. This theme consists of one subtheme:

- Provide training on an ongoing basis: Some participants were of the view that the training was too short and thus it should be provided on an ongoing basis:

  "I think the minimum level of support that I might need is continuous training on this computers. Continuous, I mean now and again. Yes, because at times I might be trained now, later without some other training I could have forgotten because we might not be using the computers often"[P3].

P5 supported the same view that the training should be provided more often:

"But what I am not sure is especially with these trainings, the minute you go back now you have forgotten about what you have learnt previously".

Other participants also concur, P6 asserts:

"Like I am saying, if I can get like more training, more workshops on how to work with especially the mathematical side of things, just another workshop, or training can help".

P7 suggested that the training is provided on an ongoing basis:

"Continuous teacher training, I think it will overcome some of the problems".

4.4.6 Challenges/barriers

Although participants' responses differed when asked about the benefits of the training outcomes, and whether they make use of their newly-acquired ICT skills for challenges or barriers that they encounter at schools, they seem to point to the similar types of barriers or obstacles. However, despite the highlighted challenges, P3 gave a clearer indication that some teachers are indeed prepared to use ICT in teaching, *"I think what can be done is just to emphasise the use of technology in this modern world because without technology you can't do anything these days"*. This theme outlines the different types of barriers that were highlighted by the participants and it encompasses five subthemes.

- Lack of computer facilities: This subtheme is one of the major points that were highlighted as obstacles to the participants in the use of their newly-acquired ICT skills. This subtheme is indeed a broader concept that may range from desktop computers or laptops, infrastructure such as internet access to computer hardware tools including printers, scanners and photocopying machines.P1 noted:

  "The barrier is lack of facilities like computer laptops because we only have one, out of 11 educators, that is what I want to say. Yes, and that someone is preparing for a test and you want to use it, you have to wait until that person is finished".

P1 further states:

> *"If one educator wants to set a paper, you will not have access to that laptop to set questions for the learners. We had the facilities but unfortunately, there was a burglary in our school, and all the computers were taken."*

One other participant supported this view:
"We have one but as I'm saying it's not enough. There are 11 of us and every time we do an assessment, we are expected to type. We need to get more laptops" [P2]. This subtheme presents a major challenge since having to share one laptop may lead to discouragement, lack of interest and less opportunity to practice. P7 asserted:

> *"We need proper facilities. Remember when you use that, you also need things like protectors".*

The participant was emphasising that each teacher should have his/her own laptop and further stated:

> *"Sometimes you reach a challenge. Sometimes you use your own personal ones but to be carrying it in and out of school becomes a challenge. So we need proper facilities here".*

P12 also expressed a similar view.

> *"I think if, maybe, at each department can have the computer. We know that maybe we will rotate as a department, that today it is you, tomorrow it is somebody else".*

However, P7 highlighted a different perspective on the challenges that they encounter:

> *"We do have, but for the past six months there was a power surge, there was a municipality power failure. I think they were, you know when they stole cables sometimes they use power surge, the computers were burnt so for the past six months our computer lab has not been working. I think that is a challenge because we used to use it for research also".*

- Lack of internet access: Access to the internet is critical and was identified as an obstacle because sometimes the participants would want to use the internet for research purposes and/or for preparing their lesson plans. P6 stated:

"We need the internet because maybe in the internet we could get some information".

P7 asserted:

"Let us start with the infrastructure, we start with the infrastructure. We do not have computers that are just boxes there, so teachers are using their personal computers; access to the internet is non-existent now because the computer laboratory is not working. So that is one of the things they can assist us with".

P10 expressed a different perspective and noted the accessibility of the internet at their school:

"We do have internet access, but it is not reliable".

- Not enough printers, smartboards and overhead projectors: P9 stated:
  "I still remember the department was saying especially for maths teachers, we were supposed to get laptops, which we never got. If only we could get individual laptops, that would help us a lot. Moreover, the smartboards, which they were talking about and projectors, if at all we had projectors then I would use my personal laptop".
- Lack of support: Participants raised a concern about the lack of support from schools; for instance, when the printer or photocopying machine is broken they often go for weeks or months without it being repaired. P3 noted:

  "There could also be challenge of the printers here, yes because at times the printers will not be working and then we call a technician from outside which if we are well-trained and well equipped with the printers there will not be any need of calling someone from outside the school".

  P4 asserted:

  "Lack of support is broad, because what we do in the case of power failure unless maybe the school if maybe they install generators or bring them in such a way that when we do not have power automatically, generators start giving us, you know, electricity in that form".

- Lack of access to the computer lab: There were some of the participants who stated that they sometimes struggle to use the computer lab as it is shared with the learners. P6 noted:

"Yes, not exactly because you see the computers that are here are used, I will show you they are the ones that we are using, but they are not working now. So the ones that are there they are used by the admin people and then we also had a computer, but it is for the learners, not the teachers".

P12 expressed a similar view:

"Moreover, going to the computer lab and then find out that there are so many learners who want to use the computer".

P3 asserted: *"Yes, computers are there for the learners in the computer lab".*

4.4.7 Interventions

Participants gave alternatives as interventions that may be performed to address some of the challenges that they have raised. This theme is sub-categorised into two subthemes.

- Provision of one ICT coordinator per school: This subtheme was raised as a key issue that needs to be addressed at the school level to deal with some of the challenges that the teachers encounter on a daily basis. P7 noted:

  "We do need especially these computer literacy technicians. Someone who is there all the time".

  This view was highlighted as a necessary intervention that can assist teachers when they experience ICT-related challenges.

- One laptop one teacher: Some participants noted that the lack of computer resources is a major challenge that contributes to the low levels of ICT use when teaching and learning. P1 stated:

  "We need enough resources in terms of computers because at the moment they've got only one laptop. If we can have maybe a computer laptop for each educator and also to be updated in terms of how to use the computer laptop, maybe once per month on how to use a laptop and also if we can have learners and teachers to have tablets".

  P1 further stated:

  "I think if each educator had his or her own computer laptop, I think it was going to be easy to administer ICT in teaching".

4.5 SUMMARY OF INTERVIEW RESULTS

The qualitative data collected from interviews is summarised as follows:

- There are low levels of ICT use in teaching, which is similar to what was uncovered from the survey data. These are largely influenced by a range of challenges, one of which is the sharing of computer facilities at schools that was highlighted by a number of the interviewed participants as one of the major obstacles. Two of the participants indicated that as a department of 11 teachers, they often have to share one laptop and this is negatively affecting them, as they always have to take turns to use the laptop.
- There was consensus that the training programme outcomes enabled some of the participants to perform their teaching activities much better such as recording marks, and typing tests/exams with one participant stating that s/he no longer does things like calculating marks manually, s/he instead uses formulae for that purpose. It also emerged from the data that teachers were also able to perform other activities such as statistics to determine the number of learners who passed or failed and the averages. This is positive feedback, which highlights the fact that some participants have gained additional skills over and above what was initially intended by the training programme that is assisting them to perform their administrative tasks.
- There was a concern that was raised which relates to the issue of having few computer facilities and those that are there being stolen or when broken not being repaired urgently. One of the participants suggested that institutions such as the GDE should provide support regarding getting ICT coordinators at schools. This is because the teachers themselves at times carry out the support and maintenance of the computer facilities. Some participants have also suggested that they need to have internet connections as it can help them to do online research for their teaching activities.
- Participants also identified lack of advanced training and lack of time as other major barriers. The survey results showed that participants believed that the training programme was good quality. Some participants stated that the training was good and had exceeded their expectation, while others felt that it was too basic and did not meet their expectations; they wanted to learn more about using

computers. Other participants stated that the training on an ongoing basis would help them improve their skills.

4.6 CHAPTER SUMMARY

Chapter4 presented the research results encompassing the surveys and the interviews. The survey results were analysed using simple descriptive data analysis techniques and presented using charts. Most of the participants taught mathematics; consequently, they emphasised issues pertaining to mathematics teachers in particular. The surveys showed that although a significant number of participants do experience challenges regarding the availability of computer facilities at their schools, they still make an effort to use ICT. They use it when preparing and presenting lessons and for administrative purposes such as recording marks or creation of class registers. Participants noted that while the training improved their computer literacy levels they still required some level of support, including having a technician or ICT coordinator at their schools.

The second section of the chapter summarised the interview results, highlighting a trend similar to that in the surveys. The results indicated that the dearth of ICT use in teaching emanates from the lack of computer facilities and technical support at schools. However, some of the participants were of the view that the training programme has helped them to prepare their lesson plans, set question papers, prepare marksheets, and perform other administrative tasks such as generating statistics and calculating averages. The following chapter explores the research results and proposes alternative ways of using ICT in teaching and learning.

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

Chapter 4 outlined the research findings from data collected in the surveys and interviews. The chapter is divided into two sections, one focusing on the survey results, and the other on the interview results. The summary statements on each section concluded the analysed quantitative and qualitative data components.

In this chapter, data analysis for both the surveys and the interviews is discussed and interpreted. The chapter further interrogates some of the responses in the questionnaires and interviews, and examines whether previous studies evinced similar conclusions. The chapter also identifies improvements and considerations when using ICT in teaching, and concludes by providing responses to the research questions.

5.2 INTERPRETATION OF THE RESULTS

The research study's primary concern was to find out whether teachers trained at the Sci-Bono Discovery Centre utilise their newly-acquired ICT skills, and attempts to answer the main research question and sub-questions. The research study used two analytical methods to analyse the quantitative and qualitative data components: simple descriptive data analysis and thematic content analysis.

The research results reveal that some of the participants viewed the training in a positive light; this was evident during the surveys when participants stated that the training was good with some of them stating that it was in fact excellent. When asked during the surveys to express their view(s) about what they learned through the training, it was evident that most of the participants were satisfied about the training that they received and none expressed a negative view about the training. This question was probed further during the interviews and that is where some of the negative views started to emerge. One interviewee confirmed that "*the training was good and quite helpful*" *[P9]*, however, some differed as P1 asserted "*Actually the training was basic*" and P4 had more expectations, "*I expected more than what I got*", while others felt that it was inadequate and too short.

The surveys indicated that the usages levels spread per week were very low with a maximum of 30% for both 2 to 3 days per week and everyday use, although participants were not asked to mention specifically what they use them for. This statistic shows a slight improvement as compared to the study commissioned by the GDE in 2011 with 10 schools, which were discussed in the literature review chapter. They revealed that the average usage of ICT for teaching and learning are at the lowest at 13% and 14%, which is even lower than the usages for administration (28%) and preparation (23%). This is very different from the international benchmark, which averages over 80% per week (ICILS 2013, discussed in the literature review chapter). The study revealed that three out of five secondary school teachers use ICTs at least once in a week. However, some participants highlighted the lack of equipment as an inhibiting factor in terms of using their newly-acquired skills. During the interviews, participants were asked a question about the tasks for which they use ICTs and this was done deliberately in order to extract more data about the specific usages. Some of the participants stated that they make use of ICT in their teaching activities, as P3 asserted, *"I use Word when preparing work schedules and daily lesson plans"*. Another participant stated, *"mostly, I use Word to prepare my worksheets" [P7].* These are clear indications that ICT is being used for both teaching activities and administrative tasks. These assertions indicate that the training has helped some participants to be more efficient when performing their teaching as well as their administrative tasks. One participant went further during the interviews to state that *"the training has helped me to be more efficient in my record keeping because all of our working marksheets have to be computerised. That is no longer a problem" [P9].* This assertion by P9, shared also by other participants, highlights the fact that training has positively influenced the teachers' approach to performing their teaching activities.

During the surveys, it was clear that some participants use the computer facilities for lesson preparation and presentation, record keeping, making notes, and preparing tests/exams as all of them were rated above 60%. Participants were asked to elaborate further on how they use the ICT tools such as Microsoft Office to prepare and present their lessons during the interviews. Indications were that they use the Microsoft Office tools to prepare and present lessons, prepare worksheets and work

schedules, which are all administrative in nature. Hinostroza (2018) warned about this approach and stated that the use of ICT in teaching and learning activities is happening much more often outside the classroom context with most frequent activities being those related to lesson preparation. Fernandes et al., (2018) asserted that teachers continue to use ICT mostly for formal academic tasks such as obtaining information from the Internet or administrative purposes such as developing lesson plans, worksheets, and assessment tests and not as a tool to support active learning. However, some few participants seemed to use the ICT tools in their classroom activities, one participant asserted, "*I present the lesson through the PowerPoint to learners, and then their response is going to be in the form of a class activity in their workbooks*". Another participant stated that "*Normally we use PowerPoint in terms of giving the learners some definitions you know in mathematics they have got some definitions*". With this type of approach, it is clear that some teachers are not only using their ICT resources for administrative tasks as asserted by Fernandes et al. (2018), but they are in fact using them for active learning in the classroom.

The survey results further showed that most schools have computer resources; however, during the interviews it was found that ten or more teachers had to share one computer laptop, which is an indictment of the state of affairs at schools. This is a major obstacle for the teachers that can lead to low morale and lack of interest in the use of ICT for teaching activities. The lack of computer resources at schools seems to be a major obstacle to the use of ICT in the classroom. P1 asserted, "*the barrier is lack of facilities like computer laptops because we only have one, out of 11 educators".* The response given above correlate well with the statement by Mustafa (2014:81) that "school facilities will definitely strengthen the teacher's sense of ownership and help in changing their work patterns".

Chen et al. (2012) observed that some teachers might rarely use ICT in the classroom because of the lack of resources and training. Moreover, when teachers seek alternative resources, they find that they are not readily available: *"Going to the computer lab and then find out that there are so many learners who want to use the computers that are there" [P12]*. Teachers would not necessarily use ICT in teaching

and learning when they are not confident about their skills and more so when there is a lack of enough computer resources at their school. P3 expressed a similar view:

“Once the teacher does not know how to use the ICT in front of the learners, there is no way that teacher can deliver lessons with these smartboards”.

According to Bingimlas (2009:240) “lack of access to resources including home access, is another complex barrier that discourages teachers from integrating technologies into education”. The comment made by P3 may also be attributed to two types of barriers, namely lack of confidence and technological illiteracy. Lack of confidence forms part of intrinsic barriers,and can only be addressed by the teacher. However, the technological illiteracy barrier, which is an extrinsic type of barrier, is brought about by the lack of technology-related training, and can be addressed by training institutions (Tedla, 2012).

The findings about the lack of resources as indicated by some participants such as P9are critical as they highlight a barrier that inhibits the teachers from utilising and practising their newly-acquired skills, notwithstanding their positive views about training outcomes. There were participants who acknowledged during the surveys that their ICT skill levels had improved after attending the training, and they were now able to perform administrative activities such as the recording marks, maintaining class registers, and setting up tests/exams. P7 expressed a similar view:

“I will say there is improvement on the part of lesson preparation, presentation, because initially it was just the chalk board, the text book and the teacher. So there is improvement although it is not a big improvement but something is happening there”.

P7’s view shows a positive attitude towards the use of ICT in teaching and learning. It further proves that initially, participants only used chalk boards and text books before attending the training programme and that afterwards there was an improvement but not significant as noted by P3:

"There is an improvement especially in maths, just that the improvement is not sudden but there is an improvement from the introduction of these smartboards".

Judging by these responses, one can therefore conclude that participants are indeed using ICT in their teaching activities despite them being more administrative than for active learning. However, this indicates that the training has had a positive impact that brought about change in their teaching activities. Thus, the training has achieved one of its objectives, which was to train teachers to learn how to use computer tools in their teaching activities. Howell (2012) asserts that teachers need to understand how to use technology effectively and be able to determine the relevant technological tools for the learning outcomes they seek.

The results also reveal that some participants found the use of ICT in the classroom challenging, and they would therefore appreciate more training interventions: *"If I can get like more training, more workshops on how to work with especially the mathematical side of things, just another workshop or training can help" [P5].* However, it must be noted that without enough computer resources at schools, teachers' newly-acquired skills may not be fully utilised. Constantino (2014) observed that the training given to practising teachers is often not adequate for them to be able to incorporate ICT efficiently into their teaching activities. Constantino's (2014) observation is true insofar as this research study is concerned. P4 noted that *"In using this technology in class we need enough support. Maybe say once a month, facilitators, or the service providers should come to our school. Trainers should come to our school and check how we fared in using the technology. That on its own will be boosting our confidence because you may find that you are not doing it properly"*. Nevertheless, it should be noted that these were not unanimous views among all participants. Other participants had a different perspective regarding the training. Some complained that the training is too basic, while others were of the view that training had limited scope and did not cover a wide range of activities.

5.3 CONNECTION BETWEEN THE RESULTS AND ICT USE IN TEACHING AND LEARNING

Teachers need to understand how to use technology effectively, grasp the learning theories behind the practice, and know how to select the right technology for the learning outcomes they seek (Howell, 2012). The results of this research have demonstrated that the participants still have a long way to go when it comes to utilising ICT effectively to achieve desired learning outcomes. Nevertheless, it is encouraging and important that they are indeed using ICT. P2 noted that *"Yes, I am able to use it although there are still challenges. You know, mathematics it's unlike other subjects, there are a lot of things that I still have to learn for instance, if you check on our programme, the one that we are using in Grade 12 now".* The challenges they encounter do not seem to discourage teachers from trying, revealing a positive attitude.

Mishra and Koehler (2006) developed a framework called TPCK to address teachers' problems arising from an emphasis on technological knowledge for teaching purposes. This framework emphasises the requirement of three primary knowledge components, namely, technology, pedagogy, and content, for the teachers to successfully integrate ICT into teaching. The research results revealed that some participants did not attain these primary components because of several factors such as additional training, lack of enough computer resources, and even lack of proper skills. As P2 noted, "*There are a lot of things that I still have to learn"*.

Responses such as the one given by P2 corroborate well with the statement made by Howie and Blignaut (2009) that teachers should be allocated resources and then be enabled to use those resources successfully, because access to resources and the capability to utilise them effectively cannot be achieved without time, effective training, and technical support. Donnelly et al. (2011) noted that ICT training programmes do not emphasise enough the importance of learning with ICT, instead of learning *about* ICT.

5.4 IMPLICATIONS FOR TEACHERS AND SCHOOLS

The literature review chapter highlighted multiple challenges facing teachers attempting the use of ICT, including those that relate to teachers themselves, and those that are linked to the schools. Howie and Blignaut (2009) noted that schools are still lagging in the acquisition of computer facilities. The interviews revealed that a large number of participants lack facilities at schools and these continues to be a problem. Therefore, schools in partnership with the provincial department need to accelerate the acquisition of IT and ensure that there is enough technical support on site for maintenance and to resolve technical issues that occur from time to time. The research found that teachers do have an interest in using ICT in their teaching activities. P7 noted: *"So when you start involving ICT, then it becomes more interactive when learners can use computers. The teacher can use computers to present lessons, so it provides us with some variety as to the learning processes"*. Nevertheless, the lack of computer resources at schools might discourage teachers trying to use ICT if not addressed effectively.

According to previous studies, teachers' lack of confidence is the most critical factor discouraging teachers from using ICT in teaching, and is correlated with access to resources. When teachers have enough resources at their schools, they develop an interest in understanding IT tools, and strive to utilise them in their classroom activities. On the other hand, lack of technical support, time, and training are also critical factors that may be detrimental to the process of getting teachers to use ICT in the classroom. Participants in this research highlighted these challenges and noted that they should be addressed urgently. Some teachers show the initiative to assist their colleagues and attend to small technical issues that may occur, which a positive development that boosts their confidence. As P7 is asserts:

"The teachers are always coming to call me to come and assist and it is not my job. I am teaching there in class so it is a challenge so you need someone who can be here".

Howie and Blignaut (2009) noted that in South Africa one out of four schools uses a teacher to provide technical support in contrast with the international average of one

out of two schools using a teacher for the same task. This means that fewer teachers in South Africa have access to technical support. Nevertheless, having an ICT coordinator or technician at the school would boost the morale of teachers as they now have someone closer to deal with ICT-related issues. P3 articulated this clearly: *"There could also be challenges of the printers here, because at times the printers will not be working and then we call a technician from outside".*

5.5 ISSUES FOR CONSIDERATION AND IMPROVEMENT

Substantial evidence points to the fact that ICT improves the quality of teaching and learning, solves educational problems, and enhances information processing and knowledge generation. It is within this context that suggested improvements should be implemented for the effective utilisation of ICT in teaching and learning. These are presented in Table 5.1.

Table 5.1: Issues for consideration and improvement for the use of ICT in teaching and learning

Issue	Schools	Teachers
ICT use	Create a conducive environment that will enable teachers to utilise ICTs in the classroom. Encourage teachers to use ICT in the classroom.	Maintain positive attitude towards the use of ICT in teaching and learning.
Provision of ICT resources	Strive to provide adequate resources such as information technology infrastructure and software applications.	Make use of the provided resources. Continue to improve your ICT skills levels.
Training	Encourage teachers to attend the training programmes that are offered by the provincial department in partnership with the teacher-training institutions such as the Sci-Bono Discovery Centre.	Make time to attend the training programmes. Prepare before attending the training. Constantly refer to the training materials when encountering challenges.
Support	Provide continued support by ensuring that ICT coordinators or technicians are deployed at schools.	Take initiative to solve ICT-related problems. Access/request support if available.
Change management	Manage the transition. Encourage and support the new teaching approaches that include the use of ICT in the classroom.	Be open minded to try new ways of teaching. Embrace the new teaching and learning methods.

5.6 RESPONSES TO THE MAIN RESEARCH QUESTION AND SUB-QUESTIONS

The feedback provided by the participants answered the main research question and sub-questions. These are discussed below.

5.6.1 Response concerning the main research question

The main research question: "*To what extent are teachers, when teaching mathematics and physical science at secondary schools, using the ICT skills gained at the Sci-Bono Discovery Centre?"*

The answers to this critical question are suggested in the findings for the participants' responses to survey questionnaire questions 8, 9, 10, 11, and 12 and are presented in Figures 4.5, 4.6, 4.7, 4.8, and 4.9. The generally used applications for teaching activities are: Microsoft Word for lesson preparation and setting up tests/exams; Microsoft PowerPoint for lesson presentation; Microsoft Excel for record keeping; and Microsoft Outlook for emails. Just above 60% use computer facilities for lesson preparation, lesson presentation, preparation of tests/exams, and for keeping records. In terms of lesson preparation, 70% use Microsoft Word; for the presentation of lessons, 50% use Microsoft PowerPoint, and for preparing exams or tests, 80% use Microsoft Word. Microsoft Excel is the most popular tool (over 60 %) for record keeping like maintaining class registers and marksheets compared with usages of other tools, PowerPoint and Excel scores are low. This may be attributed to the complexities of those applications. PowerPoint is difficult to use, especially when incorporating figures and pictures, while Excel requires challenging formulae.
This indicates that a significant number of surveyed participants are using computer resources at their respective schools, both administratively and when teaching and learning. Further answers to the main research question were obtained from participant responses to question 4 in the interviews. The question posed was:

> *What do you find most challenging about putting the skills you learnt into practice in preparing for, and presenting, lessons?*

The interview results, in terms of lesson planning and presentation, indicated that some participants make use of Microsoft Word, Microsoft PowerPoint and/or the

smartboard. This information obtained from the interview responses seem to indicate that participants do endeavour to use ICT when teaching. Furthermore, the researcher noted that some participants at certain schools make use of a smartboard or an overhead projector because they have them installed in their classes, more specifically, in the matric classes as P2 asserted, "*I only use that smartboard with the projector*". However, several participants raised some concerns about challenges such as limited ICT facilities, follow-up training, and lack of support. Some participants highlighted the fact that they struggle with incorporating Microsoft Word in teaching mathematics, P6 states that *"the drawings especially, that is where I have challenges with some of the mathematical symbols" and* P2 asserted, "*Mathematics it's unlike other subjects, there are a lot of things that I still have to learn*". The challenge of not having enough computer resources to utilise as and when teachers need them was highlighted as a major obstacle to utilising their newly-acquired skills quite often. Consequently, in time they forget what they have learnt. P1's response captures some of the issues that the participants encounter at their schools:

> *"I think we need enough resources in terms of computers because at the moment they've got only one laptop. If we can have maybe a computer laptop for each educator and also to be updated in terms of how to use the computer laptop, maybe once per month on how to use a laptop"*.

This comment clearly demonstrates this teacher's keen interest in using his/her newly-acquired ICT skills, provided there is support from the school and the provincial government to ensure that there are enough computer resources at the school. Nevertheless, challenges will always emerge when new approaches or methods are introduced and thus even with the introduction of ICT in teaching and learning, the teachers and schools experience obstacles. The challenges that were highlighted in the research results such as the lack of computer resources and ongoing training can be addressed if there is cooperation between the different stakeholders such the government institutions responsible for education. The research results data contributed to the researcher's conclusion that the participants strive to use ICT in their teaching activities including administratively despite the challenges that they encounter.

5.6.2 Response concerning the research sub-question 1

The first research sub-question: *"What are the teacher's expectations of the training, and their thoughts and views about what they learnt through the training?"*
The answers to this question are found in the participants' responses to survey questionnaire question 15, as presented in Figure 4.12 as well as question 17, and Figure 4.14. Participants were asked what they thought of the teacher ICT training programme. This question sought to establish the participant's ideas about the type of training they received and their views about the training outcomes. Over 80% thought that the purpose of the training was to improve teaching and learning, while 60% stated that the training was about using a computer to prepare lessons. Half the participants thought that the training was about using a computer to present lessons and keep records. Most participants (60%) considered the training as good. A further 10% stated that it was excellent. However, less than 10% had views varying from fair and a few elected not to answer the question at all.

However, these questions were further probed during the interviews by asking about the participants' expectations of the training, some stated that the training did not meet their expectations while others stated that it was good and exceeded their expectations: *"I don't think there was anything actually in my opinion, the training exceeded my expectations. I'm satisfied with whatever I got there" [P2].* P3 noted that his/her training needs were adequately addressed, *"Basically I didn't see anything missing because what I expected was well addressed".* Two other participants held similar views that the training was comprehensive. P12 stated, "*Most of the things were covered*" and P10 asserted, "*We did everything, the bar graphs, all types of graphs, the line graphs, everything".* From the Sci-Bono Discovery Centre's perspective, one of the major objectives of their teacher-training programme is to provide mathematics, science, technology, and computer training for all teachers from Grade R to 12 that focuses on content mastery, assessment, and lesson plan delivery. Teachers are expected to utilise their newly-acquired ICT skills in their teaching activities. Nevertheless, P10 asserted during the interview that the training was meant, "*Just to help us to be able to calculate marks, like, using working marksheet formulae and all that stuff using the computer"*. The responses

given indicate that most of the participants understand the intent of the training programme.

Furthermore, the results of the interviews also revealed that some participants were positive about the training programme and felt that it has assisted them to keep up with the technological advances *"My view is that it is a very good programme especially for maths and science and you are always at par with the technological advancements in mathematics" [P3].*

Suggestions were made that both the schools and the DoE should implement different types of interventions including an ongoing teacher-training programme on a quarterly, semester, or yearly basis. A second suggestion was that the duration of the programme should be extended and teachers who already had basic computer skills should be provided an advanced form of training. As indicated above, objectives of the teacher-training programme from the Sci-Bono Discovery Centre's perspective is to provide computer training for all teachers that focuses on content mastery, assessment, and lesson plan delivery. The results highlighted the participants' keen interest in content mastery, and their desire to attain the objective by receiving the training programme more often.

The majority of the participants believed that the training was beneficial, and taught them to integrate computer tools in teaching and learning, thereby improving their computer skills. One participant went further and stated that *"I was hoping that at the end of the training, I will be able to take whatever it is that I've learnt and implement it" [P2]*. The research results indicate that although implementation had begun, it was progressing too slowly due to a lack of computer resources. Two participants indicated that they share one laptop in a department of 11 teachers.

The research results also revealed that some participants had hoped that the training would enhance their teaching activities. *"I was expecting the training to actually improve the teaching of mathematics" [P1].* P1 went further, expressing the hope that the training would help improve the lesson delivery, *"I expected it was going to help me with the actual delivery of the lessons"*. These two comments indicate that participants had certain expectations going into the training programme, and with

that in mind; it meant they also understood what was expected of them after having acquired ICT skills. Generally, the participants hoped to learn how to use ICT in teaching and improve their ICT skills. However, there were those who viewed the training as being too basic, and felt that there should be an advanced training programme specifically for them. Most participants stated that their computer skills had improved after attending the training.

5.6.6 Response concerning the research sub-question 2

The second research sub-question: *"What ICT resources do teachers have at their respective schools?"*

Answers to this question are suggested in the participants' responses to the survey questionnaire questions 4 and 5, presented in Figure 4.2. Most of the participants indicated that they have computer facilities at their respective schools that include printers, scanners, smartboards, data projectors, computer labs, and laptops. However, it was discovered during the interviews, that computer resources are shared among teachers and learners, and are therefore not always readily available when required. At certain schools, some of the participants identified the issue of sharing one laptop per department with 11 teachers. Having to take turns to use the laptop/computer was noted as a contributing factor to the lack of ICT use, *"Someone is preparing for a test and you want to use it, you have to wait until that person is finished" [P1].* This finding demonstrates that those participants, who indicated that they have computer facilities at their schools do not necessarily, have full and immediate access to those resources.

Furthermore, it was established that existing resources are not properly maintained or even protected. One participant stated that at their school, computers were stolen during a break in and ever since, they were not able to access computer resources because they were never replaced. The lack of maintenance of the existing computers forces the teachers to bring their own laptops, which is risky. P7 asserted: *"We need proper facilities. Sometimes you use your own personal ones but to be carrying it in and out of school becomes a challenge".* The sharing of computer

resources may present a challenge since that particular resource may not always be readily available when needed.

5.6.7 Response concerning the research sub-question 3

The third research sub-question: *"What are the possible barriers which might inhibit teachers from utilising their newly-acquired ICT skills and what could be done to overcome them?"*

The answers to this question are suggested in the participants' responses to the survey questionnaire question 6, and are presented in Figure 4.3. During the surveys, over 60% of the participants indicated that they have access to the computer facilities at their schools. It was however noted that the existing facilities are not always maintained, and as a result, they are not always in good condition.

The results revealed a shortage of facilities for each teacher, so they often have to share one laptop per department or use computer labs that are not always readily available. Lack of Internet access at schools for research and accessing training manuals was identified as a major obstacle. There are no ICT coordinators or technicians at schools to take charge of the ICT functions and maintain the IT infrastructure. The GDE envisaged each school to have at least one ICT coordinator, whose role would be to provide technical support to the teachers (The eLearning Directorate, GDE, 2011). This has clearly not happened because in some instances, teachers have had to double as ICT support technicians, which impacts their teaching role as they often are called away to assist in the computer lab, *"The teachers are always coming to call me to come and assist and it is not my job"* [P7]. Other prohibiting factors are lack of change management processes, unavailability of training manuals, loss of saved work due to computer viruses, and cable theft.

In terms of the steps that can be taken to overcome those barriers, participants were asked the following questions during the interviews:

What do you think can be done to overcome those barriers?

What is the minimum level of support that you would feel necessary to encourage you to use the ICT in teaching and learning?

Both sets of answers were derived from the manual process of analysing the interview results. Participants were of the view that to overcome these challenges/barriers there needs to be enough support from their respective schools and the GDE. Furthermore, some participants felt that the training was not sufficient due to the time constraints while others were of the view that they needed an advanced training programme. A suggestion was made that each teacher should have a laptop, so that they would be able to perform their teaching activities more effectively. *"I think if each educator had his or her own computer laptop, I think it was going to be easy to administer ICT in teaching"* [P1]. One participant proposed that there should be assistance in terms of providing a full time ICT coordinator at schools to attend to the teachers' ICT needs, *"We do need especially these computer literacy technicians, someone who is there all the time"* [P7]. This was a challenge back in 2011 when Assareh and Bidokht (2011) noted that the acquisition of service providers for the maintenance of the equipment at schools is an important factor that can facilitate the effective use of ICT in the teaching process. Furthermore, there was also a proposal to offer training programmes on an ongoing basis to recap what they have learnt and improve their computer skills levels. Again, this would also need to come from the provincial department as the custodian of the ICT teacher-training programmes working in partnership with the training institutions such as the Sci-Bono Discovery Centre. The supply of enough computer resources and maintenance thereof was also raised as another critical matter, which has to be carried out by both the schools as well the provincial department. Schools can contribute by looking for sponsors such as private companies that can donate their old computers/laptops and other ICT-related resources such as servers for network or internet connections. If these measures were to be implemented, they would go a long way in resolving some of the challenges that teachers encounter at their schools.

5.7 CHAPTER SUMMARY

This chapter discussed the research results, by

- an overview interpretation of the research results;
- identifying commonalities between these research results and existing ICT use in teaching;
- implications of the results for the teachers and the schools;
- identifying issues for consideration and improvement relating to both the schools and the teachers; and
- responses given to answer the main research question and sub-questions.

The interpretation of the research results strived to give an overall summary of what was obtained in the fieldwork during the surveys and interviews. The results showed that participants expressed a general view about the lack of computer resources at their schools and the need to have training provided more often or on an ongoing basis.

Based on the research results some implications for both the schools and the teachers were discussed and culminated in the identification of the various issues for consideration and improvement. The chapter concludes by presenting and discussing the responses to answer the main research question and each of the research sub-questions. The concluding chapter presents an overall summary of the study, makes recommendations for the use of ICT in teaching and learning, and suggests avenues for further research.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The previous chapter discussed the findings based on the feedback given through the surveys and interviews to answer the main research question and sub-questions. This chapter, Conclusion, summarises the study by highlighting the major points provided by the participants' responses to the research questions. The chapter further discusses the implications of the study, topics for future research and concludes by highlighting the proposed recommendations for the use of ICT in teaching and learning.

6.2 RESEARCH SUMMARY

The rationale behind this research study was to investigate the use of ICT in teaching mathematics and physical science at secondary schools. The targeted participants for this study were teachers trained at the Sci-Bono Discovery Centre in 2012. The researcher's view is that all the statements provided by the participants during the surveys and interviews were provided honestly, without any intention to mislead. Furthermore, the researcher acknowledges limitations in this study, including:

- The study was limited to only 16 public secondary schools within two regions of the GDE, namely Johannesburg North and Johannesburg East.
- The results and findings of this research study are not to be generalised to other schools or academic subjects and can only apply to the participants and their schools.
- The study focused only on highlighting the use of computer software tools such as Microsoft Word, Excel, and PowerPoint by teachers when preparing and presenting lessons rather than a broader definition of ICT.
- The research focused on identifying the trained teachers' own experiences and how they use and implement ICT when preparing and presenting their lessons.

The research study's main objectives were to:

- Establish to what extent the ICT skills provided by the Sci-Bono Discovery Centre are being utilised by teachers who have been trained when teaching mathematics and physical science at secondary schools.
- Identify possible barriers to the use of ICT in the preparation and presentation of subjects and lessons.
- Determine from where the barriers may emanate.

The study, rooted in an interpretivist paradigm, used a survey research design with multiple methods for collecting data, namely, questionnaires, and interviews. The sample was obtained from the Sci-Bono Discovery Centre and comprised of 30 participants, all of whom teach mathematics and/or physical science, and were trained in 2012. Questionnaires were carried out over two weeks by visiting each of the schools. Twelve participants were subsequently interviewed. A consent letter and an information sheet were handed out to each participant before the survey or interview commenced.

The study was limited to a small sample of teachers. Therefore, issues raised and discussed in the research may not be applicable to all schools within the GDE. Had the number of the participants been significantly greater, there would have been an opportunity to look at a wider range of trained teachers and to raise more issues, which would have given the research a richer statistical base to add to or confirm the conclusions being drawn, or indeed to isolate anomalies in the smaller sample.

6.3 RESEARCH FINDINGS

The research findings revealed that a significant number of the participants were eager to use ICT in their teaching activities despite several challenges. Among the identified challenges were the lack of resources at schools, lack of maintenance of existing resources, poor infrastructure, and lack of teacher competence. Tedla (2012) identified similar challenges or barriers, and noted that access to computer resources is critical for effective use of ICT in the classroom. One participant complained that repair of equipment such as a printer often takes weeks to effect, reinforcing the urgent need for an ICT support technician at the schools.

The results also indicated that most teachers were unable to utilise their newly-acquired ICT skills effectively as they often had to share one computer with others in their department. This issue goes back to the limited access to computer resources at schools that was found to be a common issue in all the schools and requires urgent intervention. One of the participants suggested that each teacher be given a laptop. However, Constantino (2014) argues that what make it difficult for countries to introduce ICT into education are the embedded costs of hardware, software, ongoing upgrades, training, and technical support. Thus, inadequate access to computer resources at schools remains the most pressing underlying obstacle to the use of ICT in teaching and learning.

In the discussions shown in chapter 5, some teachers indicated in response to research sub-question 2, that they do in fact have computer resources at their respective schools. However, the question was generalised because it only asked about computer resources and not about their accessibility, availability, and usability. Further probing during the interviews indicated that the computer facilities referred to were inadequate because in certain instances more than ten teachers in one department were sharing one laptop. The unavoidable implication is that significantly more computer resources are required at the schools. Nevertheless, school leadership could play a major role in alleviating the resource bottleneck by looking for sponsors and asking corporate institutions to donate their old computer resources to their schools.

Some of the participants expressed views about the lack of ICT competence or technological literacy at school level, and called for the training to be provided more often to help them improve their ICT skills. An ongoing training programme for teachers is vital, as it will serve as a tool for enhancing effective instruction (Tedla, 2012). The discussion chapter outlined these factors in detail by quoting some of the participants' responses to the interview questions where they highlighted the need for an ongoing training programme to recap and improve on their existing computer skills. Management of the schools should encourage the teachers to attend the training programmes whenever they are on offer to improve their ICT skills. Participants seemed to share the view that the training was good, which meant that it cannot be regarded as a contributing factor of the limited use of ICT in their teaching

activities. However, they raised an important issue about the training in that there must also be an advanced training programme for the teachers who already have basic computer skills. Some participants viewed it as being too basic for them.

Additional issues raised relate to the support that teachers would like to get from the schools and the government. As indicated in response to research sub-question 3, participants suggested that the provincial department of education needed to do more for the schools. This included the provision of enough computer facilities at schools, including the deployment of ICT coordinators at schools to provide ICT support to the teachers. This would ensure that their computer facilities are maintained at all times. However, the cost of rolling out ICT infrastructure and resources to all the schools in the province would be too high. The findings of this research may be useful to teachers, government departments of education, and school leaders to provide them with some of the critical pointers to lower levels of using ICT in their teaching activities.

6.4 RECOMMENDATIONS

The provincial Department of Education in Gauteng collaborated with training institutions and introduced programmes that provided teacher ICT training. The Sci-Bono Discovery Centre is one such institution that provides computer training for mathematics, science, and technology teachers from Grade R to Grade 12. It emphasises content mastery, assessment, and lesson plan delivery. The main question is what happens after the training? This study has investigated this question and based on the findings of the analysed data, reveals low levels of ICT use for teaching activities. However, contributing factors were found to be lack of access to computer resources, teacher support, and further training at schools.

Although the results of this research study may not be generalised to all the schools in the province or nationally, it is nevertheless worth taking note of the following recommendations arising from this study.

1. Schools should be better equipped with enough computer facilities, including within the classrooms, to enable teachers to use ICTs when teaching and learning.

2. The deployment of ICT support coordinators to each school to ensure that teachers' ICT needs and resource maintenance are promptly attended to.
3. Ongoing training for teachers to help them recap prior knowledge, improve their existing skills, and introduce them to the latest computer technologies and applications.
4. Over and above the basic computer skills training, mathematics and physical science teachers require ongoing training on computer applications to help them present their lessons effectively, with practical demonstrations. Some participants pointed out that they do not often utilise their newly-acquired skills, so they tend to forget them and thus require follow-up training.
5. There should be one laptop per teacher provided by the government to avoid the sharing of a laptop or computer per department because this might lead to risks such as loss of saved work, corrupted files, and inaccessibility.

Overall access to computer resources is the major obstacle to ICT education at high schools. There cannot be successful ICT use in teaching and learning without proper resources at schools. Therefore, it is critical that plans and policies are devised to equip schools with proper ICT infrastructure and support facilities.

6.5 TOPICS FOR FURTHER RESEARCH

This research study may contribute valuable information to the policy makers when they endeavour to develop and improve the education system and modernise learning environments in schools. Further research may interest educational stakeholders in the following areas.

1. Additional research with a larger population that includes teachers who recently attended an ICT teacher-training programme.
2. Additional research with participants that received their training from different training institutions.
3. Additional research to investigate the levels of organisational support, both nationally and provincially, which is given to teachers to encourage the incorporation of ICT in their curriculum and classroom activities.

The use of ICT in teaching and learning is a good idea, but not enough is being done yet!

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APPENDICES

APPENDIXA: UNISA ETHICAL CLEARANCE LETTER

UNISA | college of science, engineering and technology

Mr Thabo Garth Khomo (43425895) 2014-04-22
College of Science, Engineering and Technology
UNISA
Johannesburg

Permission to conduct research project

Ref: 120/TGK/2014

The request for ethical approval for your MTech (Information Technology) research project entitled "The use of Information and Communication Technology by Mathematics and Physical Science teachers at secondary schools" refers.

The College of Science, Engineering and Technology's (CSET) Research and Ethics Committee (CREC) has considered the relevant parts of the studies relating to the abovementioned research project and research methodology and is pleased to inform you that ethical clearance is granted for your study as set out in your proposal and application for ethical clearance.

Therefore, involved parties may also consider ethics approval as granted. However, the permission granted must not be misconstrued as constituting an instruction from the CSET Executive or the CSET CREC that sampled interviewees (if applicable) are compelled to take part in the research project. All interviewees retain their individual right to decide whether to participate or not.

We trust that the research will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Please note that if you subsequently do a follow-up study that requires the use of a different research instrument, you will have to submit an addendum to this application, explaining the purpose of the follow-up study and attach the new instrument along with a comprehensive information document and consent form.

Yours sincerely

Chair: College of Science, Engineering and Technology Ethics Sub-Committee

University of South Africa
College of Science, Engineering and Technology
Florida Park, Roodepoort
www.unisa.ac.za/cset

UNISA | college of science, engineering and technology

APPENDIX B: TRAINED TEACHER INFORMATION REQUEST LETTER (SCI-BONO)

PO Box 7

Lotus Gardens

0025

05 March 2014

The Manager: Teacher Development Unit

Sci-Bono Discovery centre

Cnr Miriam Makeba and President Street, Newtown

Johannesburg

Gauteng

2107

Request for Access to Information

Dear Zelda,

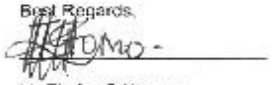
I am currently conducting a research study as part of the requirements for a Master's degree at UNISA (University of South Africa) in Information Technology.

The title of the research study is: *The Use of Information and Communication Technology by Mathematics and Physical Science Teachers at Secondary Schools*. It will focus on Mathematics and Science teachers who have recently been trained at the Sci-Bono Discovery Centre. However, I have to request permission from the Gauteng Department of Education to interview or survey the teachers and I need to identify those teachers as well as the schools in the application.

I kindly request the information regarding the teachers and their respective schools in order to finalise my application to the GDE and for the research purposes. I need to interview at least 20 Maths and Science teachers, but you can send me all the names, preferably of the area/region that falls within the Pretoria district. Additionally I would need 10 more names of teachers for subjects like Life Sciences who may have a similar profile for the Maths and Science teachers in the same region for the Pilot study.

I would like to assure you that the information will be used only for research purposes and will be held confidentially until the research study has been completed. The schools and participants will not be mentioned when writing the thesis or during publications/presentations.

Best Regards,



Mr Thabo G Khomo

Tel: 012 336 7911 Cell phone: 0721493421 Email: thabo.khomo@hotmail.com

APPENDIX C: GAUTENG DEPARTMENT OF EDUCATION APPROVAL LETTERS (2014 TO 2015)

GAUTENG PROVINCE
Department of Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no: D2015 / 056

GDE RESEARCH APPROVAL LETTER

Date:	26 May 2014
Validity of Research Approval:	26 May 2014 to 3 October 2014
Name of Researcher:	Khomo T.G.
Address of Researcher:	P.O. Box 7
	Lotus Garden
	0025
Telephone Number:	012 335 7911; 072 149 3421
Fax Number:	086 718 1041
Email address:	thabo.khomo@hotmail.com; 43425895@mylife.unisa.ac.za
Research Topic:	The use of Information and communication Technology for Mathematics and Physical Science Teachers at Secondary Schools
Number and type of schools:	SIXTEEN Secondary Schools
District/s/HO	Gauteng North; Gauteng West; Johannesburg Central; Johannesburg East; Johannesburg North; Johannesburg South and Johannesburg West.

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

2014/05/27

1

Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: Dave.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no. D2016 / 116 A
Enquiries: D. Bunding 011 843 6503

GDE AMENDED RESEARCH APPROVAL LETTER

Date:	**9 June 2015**
Validity of Research Approval:	**9 June 2015 to 2 October 2015**
Previous GDE Research Approval letter reference number	**D2015 / 056 dated 26 May 2014**
Name of Researcher:	**Khomo T.G.**
Address of Researcher:	**P. O. Box 7; Lotus Garden; 0025**
Telephone / Fax Number/s:	**012 336 7911; 072 149 3421; 086 718 1041**
Email address:	**thabo.khomo@hotmail.com; 43425895@mylife.unisa.ac.za**
Research Topic:	**The use of Information and Communication Technology for Mathematics and Physical Science Teachers at Secondary Schools**
Number and type of schools:	**SIXTEEN Secondary Schools**
District/s/HQ	**Gauteng North; Gauteng West; Johannesburg Central; Johannesburg East; Johannesburg North; Johannesburg South and Johannesburg West.**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved. A separate copy of this letter must be presented to the Principal, SGB and the relevant District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted. However participation is VOLUNTARY.

The following conditions apply to GDE research. The researcher has agreed to and may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1

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9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Machado@gauteng.gov.za
Website: www.education.gpg.gov.za

APPENDIXD: PARTICIPANT INFORMATION SHEET

Participant Information Sheet

	Question	Answer
1.	Name of researcher and contact details	Mr. Thabo Garth Khomo Email: 43425895@mylife.unisa.ac.za Cell: 072 1493 421
2.	Supervisors	Mr C.L. Pilkington Prof. I. Sanders
3.	Title of research project	The Use of Information and Communication Technology by Mathematics and Physical Science Teachers at Secondary Schools
4.	Purpose of the study	To understand the extent to which Information and Communication Technology skills that teachers have acquired through training provided by Sci-Bono Discovery Centre are being used in teaching and learning
5.	Description of the study	Academic research project for a degree which requires primary data from teachers who have attended ICT training at Sci-Bono Discovery Centre
6.	What will your (participant) involvement be and for how long?	Participants will be surveyed and interviewed for a time of plus/minus 60 minutes. The interview will be audio recorded
7.	What will happen to the information which will be given for the study?	The survey and interview information will be held confidentially until destroyed
8.	Who has reviewed this study to ensure that it complies with all the requirements and ethical standards of the University?	The Ethics Committee of the University of South Africa (UNISA) approved this research proposal and granted permission for the research to commence

APPENDIXE: CONSENT LETTER

Letter of Consent

I, _____, agree voluntarily to participate in the research study that is being conducted by Mr Thabo Khomo as part of the requirements for his Master's degree at UNISA (University of South Africa). Any question(s) which I have were answered to my satisfaction.

I understand that the information which I will supply is confidential and that it will be anonymous and can only be used in the findings of this research study.

I also understand that I do not have to answer all the questions which may be put to me.

The information which I provide will be held confidentially until the research has been completed after which it will be destroyed.

The information which I provide will not be used for any other purpose.

I understand that I am entitled to ask for a copy of the research report at the end of the research project.

I have been informed that I may withdraw from the study at any time and that any information that I have provided, and records related to my participation in this study, will be destroyed afterwards.

Signature : _____

Date : _____

APPENDIXF: SURVEY QUESTIONNAIRE

Research Questionnaire

[Topic: The Use of Information and Communication Technology by Mathematics and Physical Science Teachers at Secondary Schools]
Choose one or more answer(s) were applicable.

1. Which of the two subjects are you teaching?
   - ☐ Mathematics
   - ☐ Physical Science
   - ☐ Both

2. How long have you been teaching mathematics (*if applicable*)?
   - ☐ Less than a year
   - ☐ 1-2 years
   - ☐ 3-4 years
   - ☐ 5-6 years
   - ☐ More than 6 years

3. How long have you been teaching Physical Science (*if applicable*)?
   - ☐ Less than a year
   - ☐ 1-2 years
   - ☐ 3-4 years
   - ☐ 5-6 years
   - ☐ More than 6 years

4. Are there computer facilities at your school?
   - ☐ Yes
   - ☐ No

5. Which of the following computer facilities do have? (*you can select more than one answer, if applicable*)
   - ☐ Printer
   - ☐ Scanner
   - ☐ Data projector
   - ☐ Smart board
   - ☐ Computer lab
   - ☐ Laptop
   - ☐ Other (*pleasespecify*) _____
   - ☐ None

6. Do you have access to them?
   - ☐ Yes
   - ☐ No
   - ☐ Not all of them (*pleasespecify*) _____
   - ☐ Not at school (*pleasespecify*) _____

7. How often do use the computer facilities?
   - ☐ Everyday

- ☐ 6-7 days per week
- ☐ 4-5 days per week
- ☐ 2-3 days per week
- ☐ Less than once a week
- ☐ Never

8. What do you use them for?(*You can select more than one answer, if applicable*)
   - ☐ Preparing lessons
   - ☐ Presenting lessons
   - ☐ Making notes
   - ☐ Preparing test/exam
   - ☐ Keeping records
   - ☐ Emails/internet

9. Which of the following Microsoft Office tools do you regularly use to prepare lessons? (*You can select more than one answer, if applicable*)
   - ☐ None
   - ☐ Microsoft PowerPoint
   - ☐ Microsoft Word
   - ☐ Microsoft Excel
   - ☐ Microsoft Outlook
   - ☐ Other (*pleasespecify*) _____

10. Which of the following Microsoft Office tools do you regularly use to present lessons? (*You can select more than one answer, if applicable*)
    - ☐ None
    - ☐ Microsoft PowerPoint
    - ☐ Microsoft Word
    - ☐ Microsoft Excel
    - ☐ Microsoft Outlook
    - ☐ Other (*pleasespecify*) _____

11. Which of the following Microsoft Office tools do you regularly use to prepare test/exam? (*You can select more than one answer, if applicable*)
    - ☐ None
    - ☐ Microsoft PowerPoint
    - ☐ Microsoft Word
    - ☐ Microsoft Excel
    - ☐ Microsoft Outlook
    - ☐ Other (*pleasespecify*) _____

12. Which of the following Microsoft Office tools do you regularly use for record keeping? (*You can select more than one answer, if applicable*)
    - ☐ None
    - ☐ Microsoft PowerPoint
    - ☐ Microsoft Word
    - ☐ Microsoft Excel
    - ☐ Microsoft Outlook
    - ☐ Other (*pleasespecify*) _____

13. Rate your Microsoft Office tools skills level before the training?

Ms Office package	**Very basic**	**Basic**	**Average**	**Advanced**	**Very advanced**
Word					
Excel					
Powerpoint					
Outlook					

14. Rate your Microsoft Office tools skills level after the training?

Ms Office package	**Very basic**	**Basic**	**Average**	**Advanced**	**Very advanced**
Word					
Excel					
Powerpoint					
Outlook					

15. What are your thoughts about the purpose of the training? (*you can select more than one answer, if applicable*)
    - ☐ To improve teaching and learning
    - ☐ To train teachers on using computer tools when preparing lessons
    - ☐ To train teachers on using computer tools when presenting lessons
    - ☐ To train teachers on using computer tools for record keeping
    - ☐ To train teachers on using computer tools when preparing tests
    - ☐ To improve teacher ICT skills
    - ☐ Other (*Please specify*) _____

16. What did you hope to gain from the training?
    - ☐ Learn computer skills
    - ☐ Improve computer skills
    - ☐ Learn how to integrate computer tools when teaching
    - ☐ Improve teaching by incorporating computer tools
    - ☐ Other (*Please specify*) _____

17. What is your view about what you learnt at the training?
    - ☐ Excellent
    - ☐ Good
    - ☐ Fair
    - ☐ Bad
    - ☐ Other (*Please specify*) _____

18. Answer the below questions by choosing one of the following options

Questions	**Strongly agree**	**Agree**	**No answer**	**Disagree**	**Strongly disagree**
I use computer tools to present lessons					
I use computer tools to					

prepare test/exam					
I use computer tools to make notes					
I use computer tools for record keeping					
I use computer tools for emails or internet					
I do not use computers in my lessons because I do not have enough technical support					
I do not use computers in my lessons because of lack of facilities					
I do not use computers in my lessons because I believe in the traditional methods of teaching and learning					
I do not use computers in my lessons because I do not have enough technical support					
I do not use computers in my lessons because there is not enough organisational support					
I do not use computers in my lessons because of lack of computer maintenance					

APPENDIXG: INTERVIEW QUESTIONS

Research Interview Questions

[Topic: The Use of Information and Communication Technology by Mathematics and Physical Science Teachers at Secondary Schools]

1. What were your expectations of the training?

2. Was there anything missing from the training or what would you have liked to see, but was not there?

3. What is your view(s) about what you have learnt through the training?

4. What do you find most challenging about putting the skills you learnt into practice in preparing for, and presenting, lessons?

5. Do you, and if so, how do you, use Microsoft Office in preparing for, and presenting, your lessons? e.g Word, Excel, Powerpoint & Excel

6. Are there any challenges that you encounter when using the computer facilities? What are those challenges?

7. What do you think can be done to overcome those challenges?

8. What is minimum level of support that you would feel necessary to encourage you to use ICT in teaching and learning?

9. What do you consider barriers or obstacles to the use of ICT in teaching and learning at your school?

10. Is there any improvement in the teaching and learning of your subject when ICT is used? What has improved?