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Faculty of Education

Integrating computers into mathematics education in South African schools

by

Petronella Elize Saal

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Declaration

I, Petronella Elize Saal, student number 12382206 hereby declare that this dissertation, "Integrating computers into mathematics education in South African schools" submitted in accordance with the requirements for the Magister Educationis degree at the University of Pretoria, is my own original work and has not previously been submitted to any other institution of higher learning. All sources cited or quoted in this research paper are indicated and acknowledged with a comprehensive list of references.

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17 January 2017

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Dedication

I dedicate this research to my children
Vaelyn L'Amoure and Xpakhte Ankh Myeni.

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Abstract

The purpose of the study was to determine how South African mathematics teachers were integrating computers into their classrooms. The study was a response to the low achievement scores in mathematics as attained by grade nine learners in the 2011 Trends in International Mathematics and Science Study (TIMSS). TIMSS 2011 assessed Grade four and eight learners. However, South Africa as well as Botswana and Honduras opted to administer the Grade eight assessment to their Grade nine learners instead. South Africa's Grade nine learners achieved an average score of 352 (35.2%) out of a possible 1 000 points.

This quantitative secondary data analysis study utilised data collected from mathematics teachers from 298 schools in South Africa. The dataset was analysed using descriptive analysis that included percentages as well as the Pearson two-way Chi-square tabulations. The major finding of the study is that 73. 9% of South African mathematics teachers are still not integrating computers into mathematics education. Results showed that teachers are mostly using computers for preparation (35.5%) and administration (65.3%) purposes. Even though 45.5% of the teachers reported that they feel comfortable using computers, others feel that they are still in need of technical support. Moreover, the findings showed that 64.8% of the teachers do not attend professional development programmes that focus on the integration of Information Technology (IT) into mathematics.

Key words: computer integration, mathematics education, TIMSS 2011, secondary data analysis, quantitative approach.

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TO WHOM IT MAY CONCERN

This is to confirm that the thesis titled ***Integrating computers into mathematics education in South African schools*** by Petronella Elize Saal was proof read and edited by me.

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Please note that no view is expressed in respect of the subject specific technical contents of the document or changes made after the date of this letter.

Kind regards

Anna M de Wet

BA Hons (Cum Laude), University of Pretoria

List of abbreviations

ADDIE	Analysis, Design, Develop, Implement and Evaluation
ANAs	Annual National Assessments
ASSURE	Analysis, State objectives, Select methods, materials and media, utilise the materials, Require learners' response and Evaluation
CAS	Computer Algebra Systems
CD	Compact Disk
CPD	Continuous Professional Development
DBE	Department of Basic Education
DGS	Dynamic geometry systems
DoE	Department of Education
DPRC	Data Processing and Research Center
GDE	Gauteng Department of Education
HSRC	The Human Sciences Research Council
ICTs	Information Communication Technologies
ICT	Information Communication Technology
ID	Identification
IDB	International Database Analyser Software
IEA	International Association for the Evaluation of Educational Achievement
IQCMs	International Quality Control Monitors
IRT	Item Response Theory
ISASA	Independent Schools Association of South Africa
LCE	Learner Centred Education
NDP	National Development Plan
NRCs	National Research Coordinators
PanAF	Pan African Research Agenda
SA SAMS	South African School Administration Management Software
SDA	Secondary Data Analysis

SITES	Second International Technology in Education Study
SMIRC	Science and Mathematics Item Review Committee
SPSS	Statistical Package for the Social Sciences
TIMSS	Trends in International Mathematics and Science Study
TPACK	Technological Pedagogical Content Knowledge
V.A.W	Vereniging vir Afrikaanse Wiskunde-onderwysers (Association for Afrikaans teachers for Mathematics)
VLOs	Virtual Learning Objects
WCED	Western Cape Education Department
Win W3S	With-in school sampling software
WinDEM	Windows Data Entry Manager

CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 INTRODUCTION

South Africa, as a developing country, faces major challenges in mathematics education. Mathematics education is regarded as one of the country's top priorities as stipulated in the preamble of the National Development Plan (NDP) (National Planning Commission, 2012). One of the major contributing factors is that most of the mathematics teachers do not integrate computers into teaching and learning because of barriers, for instance, lack of competence, lack of time as well as lack of motivation (Zindi & Ruparanganda, 2011; Kamau, 2014; Chigona, Chigona & Davids, 2014). Professor of mathematics, Mamokgethi Phakeng also cautioned that there "is concern in South Africa about the state of mathematics education because it has dire consequences for the development of the country" (Naidu-Hoffmeester, 2015, p. 1). It was thus alarming that the results of The Trends in International Mathematics and Science Study (TIMSS) 2011 revealed the average mathematical performance of the Grade nine South African learners to be well below the international benchmark of 500 points (Foy, Arora & Stanco, 2013a). In fact, South Africa's mathematics and science education was ranked second-last, only outperforming Honduras. TIMSS 2015 found that the average score of South Africa's Grade nine learners were 372 out of a 1 000 (Mullis, Martin, Foy & Hooper, 2016). Again South Africa was ranked second-last, this time just outperforming Saudi Arabia (Mullis et al., 2016). The Human Sciences Research Council (HSRC) of South Africa released a media statement on the 29th of November 2016, explaining the performance of the South African Grade nine learners during the TIMSS 2015 assessment. Despite the fact that South Africa was ranked second-last, the mathematical performance improved with 20% (Reddy et al., 2015).

Research highlights the same concern: that South Africa currently faces a crisis in mathematics (Global competitiveness report, 2013). The Annual National Assessments (ANAs) results for 2014 revealed that the average percentage mark for mathematics declined for the Grade nine learners, by province (DoE, 2014). As presented in Table 1 the average mathematics marks were 13% in 2012, 14% in 2013 and 11% in 2014 (DoE, 2014).

Table 1: Mathematics average percentage mark in 2012- 2014

Mathematics average mark (%)			
Grade	**2012**	**2013**	**2014**
3	41	53	56
6	27	39	43
9	13	14	11

[Note. Adapted from: (DoE, 2014, p.9)]

The results in Table 2 reveal that just three percent of Grade nine learners had achieved more than 50% in mathematics in 2014 (Rademeyer, 2014).

Table 2: Percentage of learners obtaining at least 50% in mathematics

Percentage of learners obtaining 50% and more			
Grade	**2012**	**2013**	**2014**
3	36	59	65
6	11	27	35
9	2	2	3

[Note. Adapted from: (DoE, 2014, p.44)]

In 2010, during the State of the Nation Address, President Jacob Zuma mentioned that learners in grades three, six and nine should at least obtain an average of 60% in literacy (language) and numeracy (mathematics) (Zuma, 2010). However, it seems that only the Grade three learners exceeded his presidential targets as presented in Table 2.

1.2 BACKGROUND TO THE PROBLEM

The White Paper on e-Education (DoE, 2004), promised radical change by integrating Information Communication Technologies (ICTs) in education (Department of Education, 2004). The goal of this policy on e-Education was that: “Every South African manager, administrator, teacher and learner in general and further education and training will be ICT capable by 2013” (DoE, 2004, p. 15). It is therefore essential to determine the country's progress regarding the achievement of this goal. It seems, however, that the government's Information Communication Technology (ICT) policy is poorly implemented, especially in previously disadvantaged schools (Pan African Research Agenda, 2012). Whilst most teachers in South African public schools have attended basic ICT training, teachers are not equipped with adequate skills and the knowledge to apply the necessary skills in their teaching in a manner that enhances learner performances (Ndlovu & Lawrence, 2012).

Researchers seem to agree that teachers do not maximise the use of computers for pedagogical purposes (Lundell & Howell, 2000; Wilson-Strydom & Thomson, 2005). Only 18% of the Grade eight South African mathematics teachers are using computers in their classrooms (Howie & Blignaut, 2009). The latter authors stress the same concern, that the teachers are only using computers for administrative purposes. It is encouraging though, that a learner (aged 17) who scored the highest mathematics marks in the world is from South Africa (Somerset College in the Western Cape) (Areff, 2016). The latter reported that a student scored 100% for Mathematics International Cambridge AS level in 2015. Mathematics Cambridge International AS Level is a one year course which helps learners to develop and understand subject content that will aid them with independent thinking and in-depth problem solving (Cambridge International AS & A Levels, 2016). Areff (2016) stated that quite a lot of learners scored 100%, but this specific student was ranked number one in the world because of the quality as well as the complexity of his answers. The student revealed that he was using Project Euler to solve mathematical problems on a computer (Areff, 2016). Project Euler is a website named after Leonhard Euler, which contains a series of mathematics problems which require a level of high order thinking (Project Euler, n.d.). Stols et al., (2015) also mentioned that many developing countries, for example Asia, are exploring the use of ICTs in the classroom. Therefore the question can be asked: If the use of computers in education is increasing elsewhere, why do South African mathematics teachers seem to shy away from using computers in their classrooms?

The study aims to analyse data collected by TIMSS 2011. The following section gives a brief background of TIMSS 2011.

1.2.1 Trends in International Mathematics and Science Study

TIMSS is an assessment of mathematics and science at the fourth and eighth grades (Reddy et al., 2015). The study has been conducted by the International Association for the Evaluation of Educational Achievement (IEA) every four years since 1995 (Mullis, Martin, Foy & Arora, 2012). In the TIMSS 2011 study "45 countries" participated (Foy et al., 2013a, p. 1). In total, "608 641 students, 49 429 teachers, 19 612 principals and the National Research Coordinators (NRCs) of each country" participated in TIMSS 2011 (Foy et al., 2013a, p. 1). Countries had the option to administer the Grade eight assessment to their Grade nine learners, if the Grade eight learners were expected to find the assessment too difficult. South Africa including Botswana and Honduras were the countries which opted to administer the Grade eight assessment to their Grade nine learners.

Reddy et al. (2015), explained that South Africa changed the testing grade from Grade eight to Grade nine due to low achievement scores in the previous rounds of TIMSS. The change was made to "enable a better match between the content knowledge presented to learners in TIMSS and the curriculum coverage in South Africa" (Reddy et al., 2015, p. 3). Even though this change was made, the Grade nine learners of South Africa still obtained lower achievement scores in mathematics than the Grade eight learners of other countries (Mullis et al., 2012).

1.3 RATIONALE FOR THE STUDY

The rationale of the study is concerned with the results of the Second International Technology in Education Study (SITES) 2006 that showed that only 17.95% (see Figure 1) of the South African mathematics teachers who participated in the study use computers in their classrooms (Law, Pelgrum & Plomp, 2008). Findings indicated that the South African teachers mainly use computers for administrative purposes (Howie & Blignaut, 2009). In contrast, countries like Norway, Ontorio Canada, Denmark, Singapore and Hong Kong SAR showed massive implementation of ICTs, as illustrated in Figure 1.

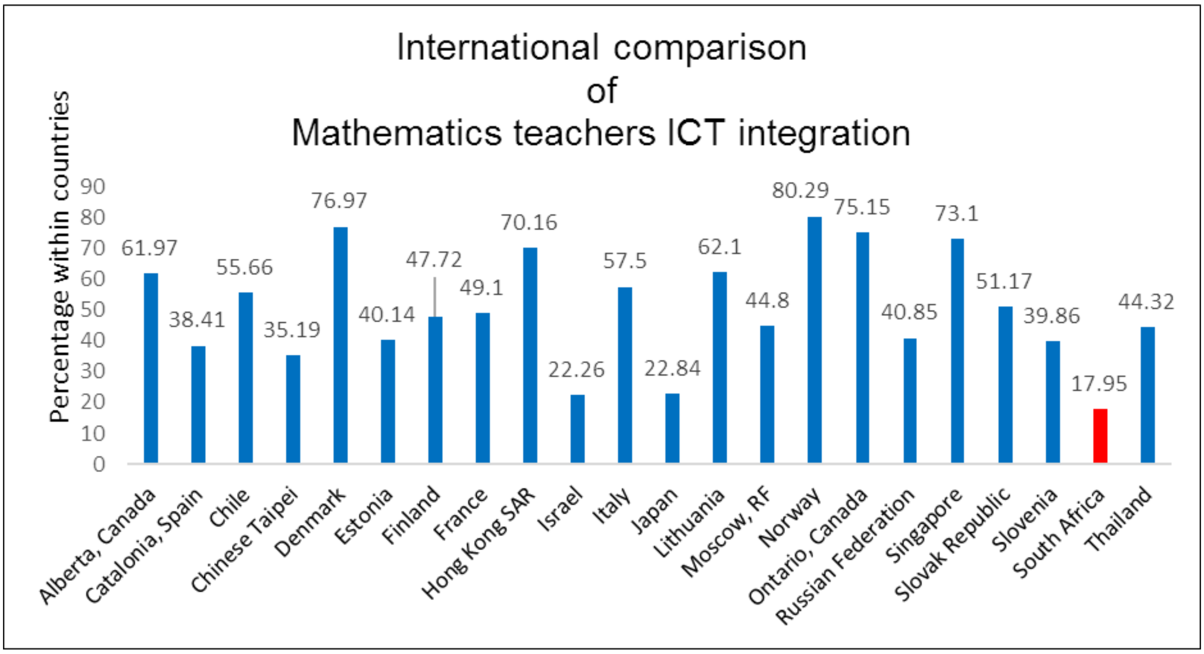

Figure 1: SITES 2006 ICT integration of mathematics teachers

[Adapted from: Law et al., 2008, p.17]

Mathematics teachers from Asian countries, that were the top performing countries in the TIMSS 2011 study and again in 2015, used computers for administration, preparation and instruction (Mullis et al., 2012). Additionally, 82% of the mathematics teachers from Singapore reported that they use computer software to supplement their teaching (Mullis et al., 2012). The study is also a response to the low achievement scores in mathematics as attained by Grade nine learners in the 2011 TIMSS. South Africa's Grade nine learners achieved an average score of 352 (35.2%) out of a possible 1 000 points. Based on the above discussion, it is therefore important to conduct a study to see how South African mathematics teachers are integrating computers in their classrooms.

1.4 SIGNIFICANCE OF THE STUDY

It is anticipated that the study may contribute to policy formation and implementation strategies. Furthermore, this study may lead to more professional development activities specifically designed for mathematics teachers. Additionally the findings may provide valuable information to schools on what type of support is needed in order for teachers to integrate computers in their classrooms. The research will also add to existing literature by investigating how South African mathematics teachers are integrating computers in their classrooms.

1.5 PROBLEM STATEMENT

In the preamble of the White Paper on e-Education the previous minister of education Ms G.N.M Pandor, stated that one of the objectives of the White Paper on e-Education is to "turn our schools into centres of quality learning and teaching for the twenty-first century" (DoE, 2004). Draper, Howie and Blignaut (2008) supported this expectation and argued that "pedagogical integration of ICTs is important for bringing changes to classroom teaching and learning so as to foster the development of 21st century skills" (p. 4). However, despite all the efforts made by the Department of Education, for example the Intel Teach to the Future project, it seems as if most of the South African mathematics teachers still do not make use of computers in the classroom (Mofokeng & Mji, 2010; Ndlovu & Lawrence, 2012; Stols et al., 2015). Teachers obviously need the necessary skills and knowledge to successfully use ICTs in their classrooms. Reasons for teachers' inability to use computers in their classrooms could have been the lack of training (Mofokeng & Mji, 2010), or little or no exposure to it (Ndlovu & Lawrence, 2012). The purpose of the study is to determine how South African mathematics teachers are integrating computers in the classroom.

1.7 RESEARCH QUESTIONS AND HYPOTHESES

This study will be guided by the following main research question:

How do South African mathematics teachers integrate computers in their classrooms?

In order to answer the main research question, the following sub-questions will be explored/investigated:

- For what purpose, and to what extent, do South African mathematics teachers use computers in their profession?
- How do the mathematics teachers perceive the support they get for integrating computers in their teaching activities?
- Have these teachers recently participated in professional development activities that focus on the integration of Information Technology (IT[1]) into mathematics?

[1] Whilst it is agreed that 'ICT' is the preferred concept in Education, the TIMSS 2011 questionnaire used 'IT' in one of its questions. In reporting on that particular question, the choice was made to remain true to the terminology used in the original question, to avoid possible semantic implications.

Hypotheses

Various hypotheses will be considered in the study. The main frame of the hypotheses is as follows:

Ho: Factor A and Factor B are independent.

Ha: Factor A and Factor B are dependent.

If the p-value is less than the significance value (α), then the null hypothesis is rejected and the two factors are dependent. On the other hand, if the p-value is greater than α, then the null hypothesis is not rejected and the two factors are independent. The set-up of each hypothesis depends on which factors are considered. For example, later in Section 4.3.1 we want to investigate whether the use of computers for preparation is dependent or independent from gender. In other words, do females tend to use computers more than males for preparation, or vice versa, or is the use of computers for preparation independent from gender. Here, the null and alternative hypotheses would be as follows:

Ho: The use of computers for preparation and gender are independent.

Ha: The use of computers for preparation and gender are dependent.

1.8 ASSUMPTIONS OF THE STUDY

The study is based on the following assumptions:

- The study assumes that the data contained in the IEA data repository are accurate, reliable and error free. The assumption is based on the fact that reliability was the measure for the consistency of the TIMSS instruments that were used in the 2011 study (Johansone, 2013). TIMSS 2011 also developed standardised operational procedures that all respondents were expected to follow. Strict quality assurance procedures were put in place which all respondents had to follow, for instance, all NRC's and their staff received "training in constructed-response item scoring and data management" (Johansone, 2013, p. 3). Furthermore, International Quality Control Monitors (IQCMs) were employed which sampled 15 schools for close observation of the administration process and data collection (Johansone, 2013).

- The mathematics teacher's questionnaire was administered to 298 schools in South Africa. The assumption is that the number of schools that participated is representative of the different categories of schools (Public, Independent and Dinaledi schools). The Independent Schools Association of South Africa (ISASA) (2016) describes public schools as schools which rely mostly on government funding. ISASA describes independent schools as schools which are privately governed (ISASA, 2016). Dinaledi schools are aimed at improving the quality of teaching and learning in mathematics and science (Buthelezi, 2012).

1.9 LIMITATIONS OF THE STUDY

Since the study was a secondary analysis of existing data, it was constrained by the limitations of the original research. Limitations include; possible sources of error, data being limited to the original number of respondents and the profile of the sample. The researcher had to rely on the quality and operations procedures of TIMSS 2011 for ensuring validity of the data, data collection methods, and so forth.

1.10 DELIMITATIONS OF THE STUDY

The study only utilised data from South Africa, even though 45 countries participated in TIMSS 2011. Four questionnaires, namely teacher, student, school and curriculum were developed by the IEA as a cooperative effort. For the current study only the data from the mathematics teacher questionnaire were retrieved.

1.11 CONCEPT CLARIFICATION

Computer

In general, the word computer can be defined as "a programmable machine or device that performs pre-defined or programmed computations or controls operations that are expressible in numerical or logical terms at high speed and with great accuracy" (Goel & Mittal, 2015, p. 1). For the purpose of the study the term computers will only refer to desktop computers and laptops, as per the original study.

Integration

Integration can be defined as the pedagogical use of ICT for Learner Centred Education (LCE) (Howie, Muller & Paterson, 2005). In this study integration refers to the mathematics teachers using computers in their classrooms.

Mathematics

Mathematics can be defined as a "human activity that involves observing, representing and investigating patterns and qualitative relationships in physical and social phenomena and between mathematical objects themselves" (DoE, 2011, p. 13).

1.12 OUTLINE OF THE STUDY

Table 3 outlines the structure of the chapters.

Table 3: Outline of the study

Chapter	Title	Description
1	Introduction	Outline the background and direction of the study.
2	Literature Review	Overview of the literature which served to clarify the central themes of the study and related research.
3	Research Design	Discussion of the research design and methods that were used to conduct the research.
4	Data Analysis	Detailed explanation of the research methods and design employed in this study.
5	Conclusion and Recommendations	A summary of the results with concluding remarks and recommendations.

1.13 CONCLUSION

The general orientation of the study was discussed in Chapter 1. Aspects such as the background to the problem, the rationale of the study and the significance of the study were described. Furthermore the research question that guided the study was also outlined. Additionally the assumptions, limitations and delimitations of the study were explained. Clarifications of concepts as well as the outline of the study were also included. In the next chapter literature about computer integration in mathematics education and the theoretical framework of this study will be discussed.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

The purpose of Chapter 2 is to categorise themes and point out gaps that emerged from literature pertinent to this study. This chapter explores literature on computer integration in mathematics education. Firstly, mathematics education is described, followed by the benefits of computer integration in the teaching of mathematics. Thereafter, the barriers to the implementation of computers in mathematics as pointed out by previous researchers will be described. The chapter outlines international and South African studies on computer integration in mathematics education. A discussion on the theoretical framework guiding this study, as well as gaps in the research, concludes this chapter.

2.2 MATHEMATICS EDUCATION

Mathematics education is considered as an important learning area (National Planning Commission, Department of the Presidency, Republic of South Africa, 2012). Mathematical skills and knowledge are also seen as key factors to boost the economic growth of a country (Parker, 2016). Mathematics is rapidly becoming part of the access requirements to enrol for many degree programmes at tertiary institutions (Sepeng, 2014). For example, learners who mastered mathematics in high school qualify to get access to universities and in return can graduate as engineers, doctors or technicians to name a few. Sadly, many South African learners perceive mathematics as difficult (Mutodi & Ngirande, 2014).

As quoted in Chapter 1, there "is concern in South Africa about the state of Mathematics education because it has dire consequences for development of the country" (Naidu-Hoffmeester, 2015, p. 1). Researchers such as Howie (2001) and the Global competitiveness report (2013) agree and highlight the same concern namely that South Africa currently faces a crisis in mathematics education. As mentioned earlier, the Department of Basic Education's Annual National Assessments (ANAs) results for 2013, revealed that the average test scores for the Grade nine learners, was 13.9% in mathematics (Rademeyer, 2014). These shocking results also revealed that just three percent (3%) of Grade nine learners had achieved more than 50% in mathematics (Rademeyer, 2014).

2.3 BENEFITS OF USING COMPUTERS IN MATHEMATICS EDUCATION

The fact that the use of ICT in education is typically beneficial for schools, teachers and learners alike, is well-reported by many scholars, for example by Oldknow and Taylor (2000). The use of ICTs in mathematics education in particular, is similarly well-reported, for example Cassim (2010), and Zakaria and Khali (2016) both reported on the benefits of the integration of computers in mathematics.

Cassim (2010) argues that schools benefit from using ICT since all the learning equipment is centralised. This means learners as well as teachers have access to resources and other information, for example via websites. In another example, teachers could communicate via Skype with parents and learners. Teachers can also post learner performances on portals for learners and parents to monitor (Cassim, 2010), consequently reducing the administrative burden of teachers (Oldknow & Taylor, 2000). With reduced administration teachers can then develop ideas, explore consequences and justify solutions with the assistance of ICTs. (Inayat & Hamid, 2016). In addition Hamdane, Khaldi and Bouzinb (2014) reported that schools use specific computer software for various administrative tasks which include: creating timetables, monitoring and tracking learner behaviour and attendance and creating learner profiles.

In their study, *"A teacher perspective on successful ICT use in secondary Mathematics teaching",* (p.1) Ruthven and Hennessy (2003) found that there are ways in which ICTs could be used to support mathematics teaching. For example, ICTs in mathematics teaching contribute to more effective working methods and improved production (Ruthven & Hennessy, 2003; Huges, 2016). Mathematics teachers from secondary schools in the study of Ruthven and Hennessy (2003) reported that by using Microsoft Excel they handle data better. This implies the production of tables and graphs are quicker, more accurate and of a better quality compared to drawing it on a black bloard (Mulaudzi, Dube, Mavhungu & Mogari, 2016). Consequently, teachers save time when they use computers for example to create graphs (Mavhungu, 2013). In addition Neurath and Stephens (2006) conducted an experimental study on the "*effect of using Microsoft Excel in a high school algebra class"* (p. 1). The experimental group was shown how to solve various problems using Microsoft Excel. On the other hand the learners in the control group were taught using traditional methods (e.g. blackboard and chalk). Neurath and Stephens (2006) found that the use of Microsoft Excel in algebra cause an increase in learner performances in algebra. It emerged that learner performances in mathematics are much higher in Asian countries like Korea, Singapore and Hong Kong, where teachers integrate computers in their classrooms (Ruthven & Hennessy, 2003; Mullis et al., 2012). As mentioned in Chapter 1, Asian countries were also the top performing countries in the TIMSS 2011 study (Mullis et al., 2012). In other countries, for example South Africa, where ICT integration is still very low (Law, Pelgrum & Plomp, 2008), learner performances in mathematics are also low (Global competitiveness report, 2013; Foy et al., 2013a; Naidu-Hoffmeester, 2015). However, there is not enough evidence that shows a significant increase in learner performance when using ICTs, therefore one cannot "draw firm conclusions" (Condie and Munro, 2007, p. 24).

Computers provided teachers with ways to improve the presentation of certain topics in mathematics. For instance, Microsoft Excel can be used in algebra (Neurath & Stephens, 2006) and to "understand the mathematical concepts such as exploring functions, patterns, probability, and statistics, mathematical modeling, and geometric transformations" (Inayat & Hamid, 2016, p. 7). Mulaudzi, Dube, Mavhungu and Mogari, (2016) as well as Mavhungu (2013) explain that Microsoft Excel assists learners to peform difficult calculations easily and quicker. In their overview *of "Integrating New Technologies and Tools in Teaching and Learning of Mathematics"* (p. 1), they discovered that, by altering certain variables in formulas, calculations update automatically (Inayat & Hamid, 2016). Spreadsheets also provide a platform of visualisation for learners in the form of pictures and chart (Cassim, 2010).

Computer Algebra Systems (CAS), for example Maple, can be used in algebra (Neurath & Stephens 2006). CAS can also be used to develop learners' conceptual as well as "geometrical understanding" (Kumar & Kumaresan, n.d., p. 373) CAS can be defined as a "software package used in manipulation of mathematical expressions in order to automate the algebraic manipulation tasks which are tedious and Several times difficult to solve manually" (Inayat & Hamid, 2016, p. 5). Maple is a type of mathematics software which allows learners to "analyse, explore, visualize and explore mathematical problems" (Maplesoft, 2016, p. 1). CAS can also be used to explore concepts, procedures and symbolic patterns (Inayat & Hamid, 2016). Above all, Kumar and Kumaresan (n.d.) in their study "*Use of Mathematical Software for Teaching and Learning Mathematics"* (p. 1) in India found that CAS helps learners, teachers and researchers. Kumar and Kumaresan (n.d.) explain that CAS helps: (1) "learners to explore realistic problems" (p. 1), (2) increase learner motivation, (3) assisting teachers with the development of innovative, more challenging tasks, including exploratory, education models and (4) researchers save time due to CAS performing computations. Therefore more time is available for analysing computations.

In addition, Dynamic Geometry Systems (DGS) such as GeoGebra can be used for manipulating and measuring shapes on a monitor (Clements, 2000). DGS can be described as "an effective mathematical tool for interactive representation and manipulation of geometric objects" that allows one to "build a geometric model" (p.4) which includes " lines, points, circles with the dependencies that relate these objects to each other" (Inayat & Hamid, 2016). Advantages of DGS includes maximising learners' understanding of geometry, while it also enables visualisation of concepts (Inayat & Hamid, 2016).

By using computers most teachers play the role of a facilitator rather than a dictator (Keong, Horani & Daniel, 2005; Zakaria & Khalid, 2016). The use of ICT enables learners to construct their own knowledge which means the use of computers promotes a learner-centred approach to teaching (Zakaria & Khalid, 2016). This approach "promotes higher order thinking and better problem solving strategies" (Keong et al., 2005, p. 2). Therefore, computers basically assist learners to work independently. Futhermore, Clements (2000) stated that learners also developed higher order thinking skills by using Logo. Logo is a programme language and environment for exploration" (p. 1) that assist learners to understand geometry concepts (Clements, 2000). ICTs also provide "support strategies of problem solving through trial and improvement" (Ruthven & Hennessy, 2003, p. 3). This means that learners cannot progess to a next question until they get the current question correct. Computers are also enhancing revision because it enables learners to see the errors they make (Ghavifekr, Razak, Ghani, Meixi & Tengyue, 2012). Above all, learners develop skills, for instance sorting (Inayat & Hamid, 2016), through “drill and practice type activities” (Cassim, 2010, p. 36). Learners receive immediate feedback compared to the traditional method of teaching (Clements, 2000; Ruthven & Hennessy, 2003; Drijvers, 2015).

While the use of computers in the classroom seemingly improves the classroom environment (Zakaria & Khalid, 2016), it can not yet be described as a breakthrough (Cheung & Slavin, 2011). ICTs such as graphing devices, do however, create an engaging environment which leads to interaction among learners, has a motivational effect, and also advances problem-solving skills (Keong et al., 2005; Neurath & Stephens 2006; Oldknow & Taylor, 2000). In a similar vein, Zakaria & Khalid (2016) reported that graphing devices provide a platform for learners to interchange knowledge as well as skills.

The Internet provides learners with “models ” (Oldknow & Taylor, 2000, p. 225) which help learners to understand mathematical concepts (Zakaria & Khalid, 2016). Furthermore, models were also developed to assist with the integration of computers in mathematics. These models include: the analysis, state objectives, select methods, materials and media; utilising the materials and assistance to apply the Require Learners’ Response and Evaluation (ASSURE) model, wich assists learners with fractions (Neurath & Stephens 2006). In addition the Analysis, Design, Develop, Implement and Evaluation software (ADDIE) was designed to assist learners with special needs with fractions, (Zakaria & Khalid, 2016). Moreover, the Buffet model provides learners with a customised learning environment based on their needs (Progress, 2015) (Becta 2003).

Even though mathematics teachers realise the benefits of ICTs into mathematics, Law, Lee, Chen and Yuen (2008) reported that ICT integration in South Africa was very low. Despite the advantages of using ICT in mathematics, barriers are still hindering the integration of ICT in mathematics. These barriers are discussed in the subsequent sections.

2.4 BARRIERS TO THE INTEGRATION OF COMPUTERS IN TEACHING AND LEARNING

A barrier is an impediment that prevents, or slows down, the accomplishment of a goal (Gal, Joan & Garfield, 1997). Researchers have identified barriers that hinder mathematics teachers from using computers in their classrooms (Bingimlas, 2009; Assude, Buteau & Forgasz, 2010; Aslan & Zhu, 2016). These barriers can be classified as exogenous or endogenous (Simelani, 2013), where the exogenous barriers include variables such as the age and gender of teachers, their ICT profile and institutional support. On the other hand, endogenous barriers include variables related to the ICT profile of the learners and finances (Simelani, 2013). However, for this study the barriers were clustered into three groups namely institutional-level barriers, teacher-level barriers and learner-level barriers (Bingimlas, 2009; Assude et al., 2010; Aslan & Zhu, 2016).

2.4.1 Institutional-level barriers

Studies internationally and in South Africa indicated that institutional-level barriers disturbed the integration of ICT in mathematics education (Assude et al., 2010; Chigona et al., 2014; Amuko, Miheso-O'Connor & Ndeuthi, 2015). Institutional barriers listed in the literature are the lack of support, professional development, hardware, software and time (Keong et al., 2005; Jones, 2004; Hennessy, Harrison & Wamakote, 2010).

The lack of support. Literature identified the lack of support as the major institutional barrier affecting the teachers integration of computers in the classroom (Snoeyink & Ertmer, 2002; Jones, 2004; Bennison & Goose, 2010; Chigona et al., 2014). In the Yogyakarta province of Indonesia, Setyaningrum (2016) surveyed 50 mathematics teachers from rural junior high schools. The purpose of the study was to investigate the perceptions of teachers towards ICT integration in mathematics. Setyaningrum (2016) findings revealed that mathematics teachers from Yogyakarta perceived ICT in mathematics as important. However, these teachers reported that they did not get enough support from their principals. Hudson and Porter (2010) conducted a study in New Zealand as well as in Australia. Their findings showed that mathematics teachers lacked professional support (Hudson & Porter, 2010). Additionally, in Nairobi, Kenya more then 50% of the mathematics teachers in secondary schools "lack support from the school administration" (Amuko et al., 2015, p. 3). Furthermore findings also showed that teachers lack "capacity building support" (Amuko et al., 2015, p. 1). In their study, "*Technological Pedagogical Content Knowledge of Secondary Mathematics Teachers*" (p. 1) Handal, Campbell, Cavanagh and Petocz (2013) found that the teachers in Australia lacked skill as well as support in order to locate various "digital resources and activities that are pedagogically productive" (Handal et al., 2013, p.15). Other studies, including Amuko et al., (2015) as well as Uwaezuoke and Ekwueme (2015) found in their research that teachers lacked technical and pedagogical support.

In their study, "*Educators' motivation on integration of ICTs into pedagogy: case of disadvantaged areas",* Chigona et al., (2014 p. 1), during an interview, found that the teachers in disadvantaged areas in Western Cape were not happy with the amount of time they had to wait for technical support. One of the participants in their study mentioned:

> "*They (*Technical staff of the Khanya project*) give you a little reference to keep you quiet and whether they are going to come today, tomorrow or next year doesn't matter…you just need to wait…the support isnt that great*" (Chigona et al., 2014, p. 5).

In other words, teachers (in the disadvantaged areas in particular the Western Cape) are not happy with the quality of technical support provided by the Khanya project. This indicates the need for readily available technical support. This is essential for teachers since a technical issue arising during a lesson can prevent teachers from continuing with the lesson. Technical issues cause teachers to be less motivated and it also wastes time since the teacher has to wait for the technician (Chigona et al., 2014).

What was derived from Chigona et al., (2015) was that even if the school had technical staff, in most cases they could not attend to the problems of the teachers immediately. Technical staff are not only needed to assist teachers with hardware and software related issues, but they are also required for maintainance of the infrastructure (Dotong, Castro, Dolot & Prenda, 2016).

In addition, SITES 2006 found that technical support for South African mathematics teachers was the lowest among 22 education systems (Howie & Blignaut, 2009). Furthermore, Dotong et al., (2016) are of the opinion that secondary schools' main focus remain on the computer literacy skills of teachers rather than on how to apply ICT skills in a specific subject. Basically, what these researchers are saying, is that in order for teachers to integrate computers into their schools' classrooms, they should be provided with support in the form of policies (Thomas, 2006). These guidelines should focus on how to integrate computers in a specific learning area, for example mathematics. They should also have support readily available in case a teacher needs assistance.

The lack of professional development. Professional development has the potential to eliminate barriers, including the need for support. For example if teachers are trained to use ICTs they will have the necessary skills, which will in turn increase their confidence (Bennison & Goose, 2010). A number of international studies (Handal et al., 2013; Kamau, 2014 ; Akkaya, 2016) indicated that the teachers lacked effective training in ICTs. The need for professional development is critical, "not only for the mastery of tools themselves but also for their pedagogical application to specific learning objectives" (Handal et al., 2013, p. 15).

In addition, Bennison and Goose (2010) investigated the professional development needs of 485 mathematics learners in Australia. Their results showed that 400 (83%) of teachers indicated that they did attend training in ICT. However, the teachers still expressed a need for Continuous Professional Development (CPD) to effectively integrate ICT into teaching and learning. The researcher agrees with Bennison and Goose (2010), that teachers need CPD to be up to date with the everchanging technology. In contrast with Bennison and Goose (2010), Leendertz, Blignaut, Niewoudt, Els and Ellis (2013) found that from the 640 South African mathematics teachers who participated in SITES 2006, only 96 (15%) indicated that they had previously participated in an ICT training event.

Hardware-related barriers. Mathematics teachers in Australia are of the view that one can not integrate ICTs into teaching because of the lack of resources such as data projectors (Handal et al., 2013). While a few teachers do have access to adequate ICT infrastructure, such as SmartBoards, data projectors, computers, speakers etc., they often do not have the time needed to get familiar with these resources. An insuffient number of computers (Kamau, 2014), lack of computers for learners with special needs (Howie & Blignaut, 2009), lack of Internet access (Zindi & Ruparanganda, 2011) and a lack of electricity (Amuko et al., 2015) are school-level barriers preventing teachers from using ICT in mathematics education. Kihoza, Zlotnikova, Bada and Kalegele (2016) make use of a mixed method approach regarding the abilities of teachers to "support blended learning implementation" (Kihoza et al., 2016, p. 1). The sample included 235 participants from four secondary schools in Tanzania. Findings revealed that two of the schools in their study had no ICT infrastructure "except for one laptop and one photocopy machine" (Kihoza et al., 2016, p. 17). Moreover, they found that the laptop and photocoy machine were in the offices of the principals and could only be used for "managerial issues and examination processing" (Kihoza et al., 2016, p. 17).

On the other hand, in cases where schools did have computers readily available, teachers were experiencing difficulties accessing them (Zindi & Ruparanganda, 2011; Chigona et al., 2014). For example, teachers in the rural areas of Cape Town, South Africa are hesitant to use computers, because they don't have the freedom to use the computers whenever they want (Chigona et al., 2014). For instance, one of the respondents from Chigona et al., (2014) stated that the coordinators of the Khanya project "prescibe who can use the ICT infrastucture and when it can be used" (Chigona et al., 2014, p. 5). The same resondent from Chigona et al., (2014) also indicated that "the rules attached to the Khanya project are too strict" (Chigona et al., 2014, p. 5).

The lack of internet access as a barrier to ICT in South Africa was also reported by mathematics teachers who participated in SITES 2006 (Leendertz et al., 2013). Only five (1%) from 504 schools who participated in SITES 2006 were connected to the Internet (Leendertz et al., 2013). Furthermore, in a study on the "*Evaluation of barriers to the integration of ICT in teaching and learning of science and mathematics in Zimbabwe's secondary schools"* (p. 1) Zindi and Ruparanganda (2011) found that schools in Zimbabwe with Internet connection have an unreliable connection.

Software-related barriers. There are a large number of ICT tools avalable for mathematics instruction, for example, CAS and DGS (Inayat & Hamid, 2016). CAS include programmes such as Maple and DGS includes, for example, GeoGebra (Kumar & Kumaresan, n.d.). Clear definitions of CAS and DGS were explained earlier in Section 2.5. In Turkey teachers are prefer Cabri and Geometer's Sketchpad, because the software is available in Turkish and there is no cost involved. (Akkaya, 2016). However Akkaya, (2016) observed that teachers don't prefer using Virtual Learning Objects (VLOs) because it is not available in Turkish. VLOs "allows choosing variables in GeoGebra where students can interact with the formulation of mathematical problems applied to their curricula" (Valencia, 2015, para. 1). Furthermore, Vietnamese teachers are also not integrating ICTs due to linguistic issues (Dotong et al., 2016). Only 50 (10%) from 504 South African schools which participated in SITES 2006 had access to tutorial software for mathematics education (Leendertz et al., 2013).

Lack of time. Teachers seem to be continuously under pressure to complete the curriculum in preparation for examinations (Kamau, 2014). A similar finding emerged from Handal et al., (2013). One of the respondents from the study of Handal et al., (2013) argued that "Time is a restricting factor and all concepts need to be taught in a very short time" (p. 13) in order for learners to write exams (Handal et al., 2013). Internationally, teachers reported that preparing and planning ICT integrated lessons were time consuming (Kamau, 2014). An Australian study, "*Learning to teach Mathematics with technology; A survey of professional development needs, experiences and impacts*" (p. 1) conducted by Bennison and Goose, (2010) found that lack of time prevented teachers from familiarising themselves with ICTs (Bennison & Goose, 2010).

Teachers in Ireland reported that insufficient time was among the most serious barriers hindering their integration of ICT (Cosgrove et al., 2014). In addition, teachers from Cape Town, South Africa, argued that the restrictions of their computer laboratory which was under the control of the Khanya project prevented them from exploiting the benefits of the ICT facilities (Chigona et al., 2014). As mentioned earlier these teachers could only use computers during certain times.

2.4.2 Teacher-level barriers

Lack of competence. The lack of ICT competence seems to be hindering mathematics teachers in their use of computers in the classroom (Zindi & Ruparanganda, 2011; Cosgrove et al., 2014; Kamau, 2014; Amuko et al., 2015). This barrier is the most frequent of the eight teacher-level barriers identified in the articles reviewed.

Literature reveals that teachers in Kenya find it challenging to develop their own computer-related skills (Amuko et al., 2015). In addition, Agyei and Voogt (2012) found that teachers (including pre-service teachers) in Ghana did not use computers in their classrooms due to lack of skills and knowledge. In their study, Leendertz et al., (2013) used data from 640 mathematics teachers who participated in SITES 2006. Leendertz et al., (2013) found that 250 (39%) of mathematics teachers reported that they lacked competence to use computers in their classrooms. Evidently, teachers who lack computer-related skills tend to lack confidence as well, and seem to have negative attitudes towards the integration of computers in their classrooms (Jones, 2004).

Lack of confidence. Mathematics teachers seem to lack confidence to use computers in their classrooms (Jones, 2004). It is argued that if mathematics teachers can be more confident in terms of their own computer skills, they may be more motivated to use computers in their classrooms (Leendertz et al., 2013). However, researchers such as Jones (2004), Bennison and Goos (2010), Leendertz et al., (2013), Cosgrove et al., (2014) as well as Dotong et al., (2016) concluded that the mathematics teachers lacked confidence to integrate computers in their classrooms. A study conducted in Australia by Bennison and Goos (2010) found that there was a relationship between professional development and the confidence levels of teachers. Results showed that teachers who participated in professional development were more confident in using computers in the mathematics classrooms. Law et al., (2008) support the finding of Bennison and Goos (2010) and reported on the findings of SITES 2006, which indicated that the relationship between competence and confidence is not just recognised in Australia, but in 22 other countries including South Africa. In addition, Dotong et al., (2016) state that teachers in developing countries do not prepare ICT integrated lessons sufficiently, which leads to them having less confidence when using computers in their mathematics lessons.

There seem to be a clear relationship between the barriers that hinders the use of computers in the mathematics classroom and professional development. Many of the barriers, as indicated in previous studies, can be limited if mathematics teachers attend professional development courses specifically designed for ICT integration mathematics (Handal et al., 2013; Leendertz et al., 2013).

Resistance to change, teacher demographics and the pedagogical beliefs of teachers. The pedagogical beliefs of teachers are influenced by factors such as age (Jones, 2004), gender and experience (Lau & Yuen, 2013) of teachers. Evidently, older teachers in China are resistant to change and cling onto their traditional way of teaching (Lau & Yuen, 2013). In general, younger teachers seem to be more eager to change their teaching style due to the changes in technology, which constantly produce newer versions of ICT equipment. Furthermore, Kukali (2013) found that teachers in Kenya believed that their workload increased since the integration of computers in their lessons. One can conclude that teachers seem to be reluctant to adopt new teaching styles unless they understand the benefits thereof.

Lack of motivation. Teachers are encouraged through various policies to integrate computers into their classrooms; however, it seems as if they are not motivated to do so (Chigona et al., 2014). Teachers are not motivated to use virtual objects in mathematics because they do not understand the language in which the software is produced (Akkaya, 2016). For example, VLOs are available in English and some teachers do not understand the language. In addition, Chigona et al., (2014) found that one of the reasons teachers in Cape Town, South Africa do not use computers in instruction, is because they are not motivated. Their results showed that "satisfaction derived from using ICTs, individual expectations, responsibility and sense of achievement experienced when using the technologies" (p. 1) had an impact on the motivation of teachers to use computers (Chigona et al., 2014).

2.4.3 Learner-level barriers

Very few studies reported learners as barriers to ICT integration. This section addresses: large class sizes, ICT competency of learners, learner attitudes as well as the availability of computers to learners at their homes.

Large class sizes. Overcrowded classrooms hinder the implementation of ICT in mathematics education (Chigona et al., 2014). Researchers argue that large class sizes are not the “desired learning environment” (Akkaya, 2016, p. 15). The researcher supports the findings of Akkaya (2016), because large class sizes can be problematic in the case where schools don’t have enough computers for teaching and learning.

ICT competency of learners. The lack of ICT skills of learners is also preventing teachers from integrating ICTs into their classrooms (Chigona et al., 2014; Setyaningrum, 2016). Teachers prefer to use computers in a classroom where the learners are competent in using computers (Chigona et al., 2014). If the learners lack ICT skills, the teacher ends up showing them how the computer works instead of teaching learners with the aid of the computer (Chigona et al., 2014). In their study the latter found that, teachers in the disadvantaged areas of Cape Town, South Africa, were not willing to use computers due to lack of readiness of learners to use ICT.

Learner attitudes. In Turkey, Goktas, Yildirim and Yildirim (2009) made use of questionnaires and interviews to investigate “The main barriers and possible enablers for integrating information and communication technologies (ICTs) in Turkey’s pre-service teacher education programs” (p. 1). The sample consisted of “223 teachers and 2,116 prospective teachers” (Goktas, et al., 2009, p. 195). Findings indicated that learner attitudes prevented mathematics teachers to integrate ICTs in their classrooms (Goktas et al., 2009).

Availability of computers to learners at their homes. Keong et al., (2005) utilised a survey to investigate “use of ICT and the barriers of integrating ICT into the teaching of mathematics” (p. 44). The survey was administered at a “mathematics in-service course conducted by the State Education Department” (p. 44). Only 111 teachers responded to the survey. Results showed that learners without computers at home are one of the major barriers to ICT integration. In addition, Guha (2000) argues that learners with ICTs at home put teachers indirectly under pressure by expecting teachers to be well informed about ICT usage.

2.5 PREVIOUS STUDIES ON COMPUTER INTEGRATION IN MATHEMATICS

This section provides a summary of previous studies on ICT integration in mathematics. This study provides an analysis of studies done internationally and nationally. Analysis includes the nature of the study, participants, and the findings. This enables the researcher to compare the integration of ICTs in mathematics internationally as well as in South Africa.

2.5.1 International studies on computer integration in mathematics

In Kenya, Kamau (2014) made use of a mixed method study to examine the factors related to technology adoption by secondary mathematics teachers in Nyandarua and Nairobi. This study was limited to 135 teachers. Surveys, interviews and observations were used for data collection. Multiple regression analysis was employed to analyse the data. The results indicated that the teachers lacked technology skills and that there was a lack of technology training.

A quantitative study by Ahmed and Osman (2016) explored the extent to which ICT is integrated into the teaching and learning of mathematics and science in Sudanese secondary schools. Stratified random sampling was employed to select 84 teachers. Results revealed that the "unavailability of infrastructure, limited time for planning and the lack of support from school administrators" (p. 1) were hindering the teachers from using computers in the classroom (Ahmed & Osman, 2016).

Phiri (2016) made use of stratified random sampling to collect data from 100 learners and 50 teachers in Zambia. The purpose of the study was to establish perceptions regarding ICT integration in mathematics education. He used a mixed method research design and utilised questionnaires and interviews. Findings showed that the learners and teachers were positive regarding the integration of ICTs in the classroom. However, barriers which include: "lack of internet connectivity, high cost of acquiring and maintaining ICT infrastructure, lack of ICT facilities and an unsupportive curriculum" (p. 1) were preventing ICT integration (Phiri, 2016).

In their quantitative study Ihechukwu and Ndidi (2016) utilised questionnaires to collect data from 150 mathematics teachers who were randomly selected by them in Nigeria. The purpose was to determine *the impediments to integration of ICT in teaching and learning in secondary schools in Imo State, Nigeria* (Ihechukwu & Ndidi, 2016). Findings showed that the mathematics teachers did not integrate computers in their lessons due to "negative attitudes of the teachers, lack of competence and confidence, poor policy implementation and lack of time and lack of personnel" (Ihechukwu & Ndidi, 2016, p. 1).

2.5.2 National studies on computer integration in mathematics

Mofokeng and Mji (2010) investigated, "*The readiness of South African teachers to use computers in their Mathematics and Science classrooms"* (Mofokeng & Mji, 2010, p. 1). The sample consisted of 58 teachers from 35 schools in the Gauteng Province of South Africa. Findings showed that teachers did not make use of computers in their classrooms at all. Additionally, results indicated that teachers did not have access to computers in their homes.

Du Plessis and Webb (2012) made use of a case study to investigate the perceptions of mathematics teachers regarding their personal as well as their schools' readiness for computer integration. The study involved 30 mathematics teachers from six previously disadvantaged schools in South Africa. The study employed a mixed method design that used questionnaires and interviews to collect the data. Their findings revealed that schools with computers and teachers who attended training are still implementing ICTs.

Leendertz et al., (2013), utilised the rich data from SITES 2006 to determine the level of Technological Pedagogical Content Knowledge (TPACK) of mathematics teachers. They also investigated whether the TPACK framework contributed to more "effective Grade eight mathematics teaching in South African schools" (Leendertz et al., p. 1). They randomly selected a sample consisting of 640 mathematics teachers from 504 schools. Findings showed that the "TPACK of teachers contributes towards more effective Grade eight mathematics teaching in South Africa" (Leendertz et al., p.1).

Stols et al., (2015) focused on exploring the perceptions and needs of South African mathematics teachers concerning the use of technology for instruction. They made use of a mixed-method pilot study. The sample of the study consisted of 22 mathematics teachers from the Eastern Cape Province. The researchers concluded that; "Teachers in general are hesitant to use computers in their classrooms" (Stols et al., 2015, p. 1). They also found that the participants of their study were reluctant to use the internet to "improve the quality of their teaching" (Stols et al., 2015, p. 12).
A quantitative study by Moraal (2015) aimed at *investigating the nature of the relationship between the pedagogical beliefs of Mathematics teachers and their use of educational technology in the classroom* (Moraal, 2015). The study was limited to seven teachers from one school in the Gauteng Province of South Africa. Moraal (2015) made use of observations and interviews to determine the teachers' use of educational technology. Moraal (2015) found that teachers with teaching-centred beliefs used computers for administration and preparation, while teachers with learning-centred beliefs applied educational technology to "promote the learning of Mathematics" (Moraal, 2015, p. 9).

In a study, published in 2015, Venter investigated *factors that influence the use of dynamic software for teaching and learning by mathematics teachers*. Venter (2015) used multiple regression to analyse data collected from the "Vereniging vir Afrikaanse Wiskunde-onderwysers" (Association for Afrikaans teachers for Mathematics (V.A.W). The sample was purposefully selected because the participants were familiar with GeoGebra. The study revealed that factors such as performance expectancy, effort expectancy and social influence had an effect on the intentions of teachers to use GeoGebra.

A qualitative study by Mulaudzi et al., (2016) investigated *the perceptions of teachers regarding the use of computers to teach graphs in mathematics*. The study consisted of nine mathematics teachers who were specifically selected. Their findings revealed that teachers in the Vhembe District in the Limpopo Province of South Africa enjoyed teaching mathematics with computers.

2.6 THEORETICAL FRAMEWORK ACTIVITY THEORY

This study is based on the principles of the first generation Activity Theory. The sections below briefly outline the background and the application of Activity Theory in the current study.

2.6.1 Background to Activity Theory

Engestrom (1987) and Leont'ev (1978) explain that Activity Theory is a conceptual framework that is suitable for research which involves human behaviour. The first generation Activity Theory originated in the 1920s from the work of a Russian psychologist, L.S Vygotsky (Kuutti, 1996). Vygotsky's Activity Theory can be represented by a triangular shape. It contains three components namely, tools or mediating artefacts, subject and object as outlined in Figure 2.

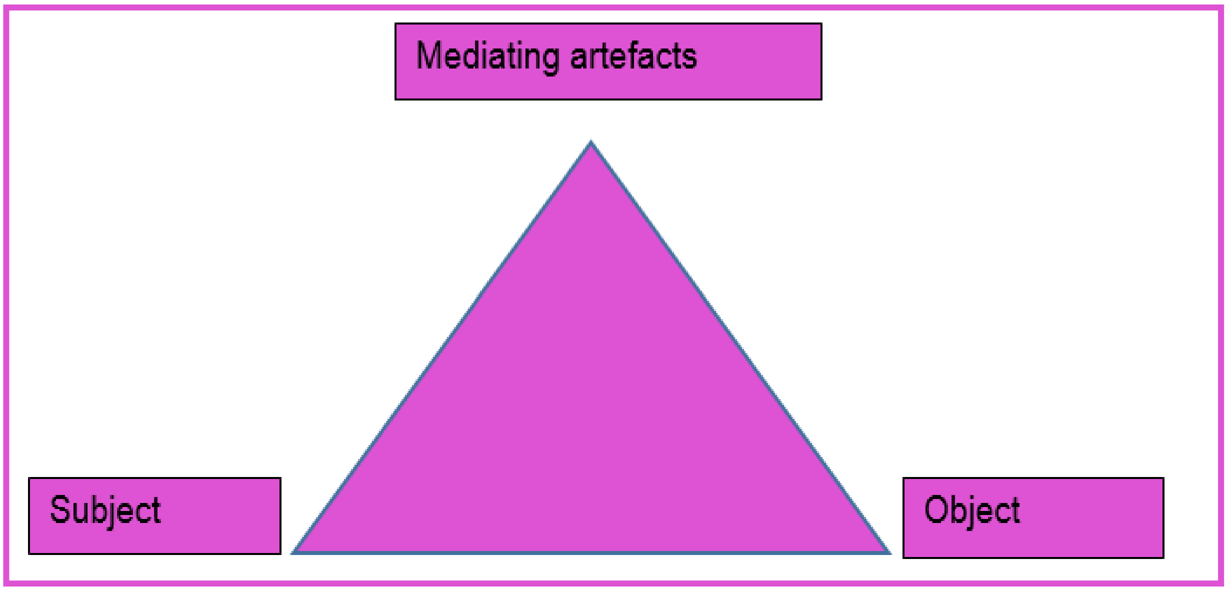

Figure 2: Components of Activity Theory

[Adapted from: Kuutti (1995)]

Activity Theory focuses mostly on an individual's actions. Hardman (2005) explained that Vygotsky's model failed to demonstrate how cognitive change occurred in a collective context. This failure provided the opportunity for one of Vygotsky's students, namely A.N Leont'ev, to develop the second generation of Activity Theory where the researcher expanded on the idea of mediation (Leont'ev, 1978).

Leont'ev made use of a hierarchical level of an activity to differentiate between an activity and an action. Leont'ev argues that a group or an individual performs an action, whereas a community executes an activity collectively. Leont'ev "conceptualised activity as three different units of analysis: activity, action and operation" as illustrated in Figure 3 (Núñez, 2009, p. 8).

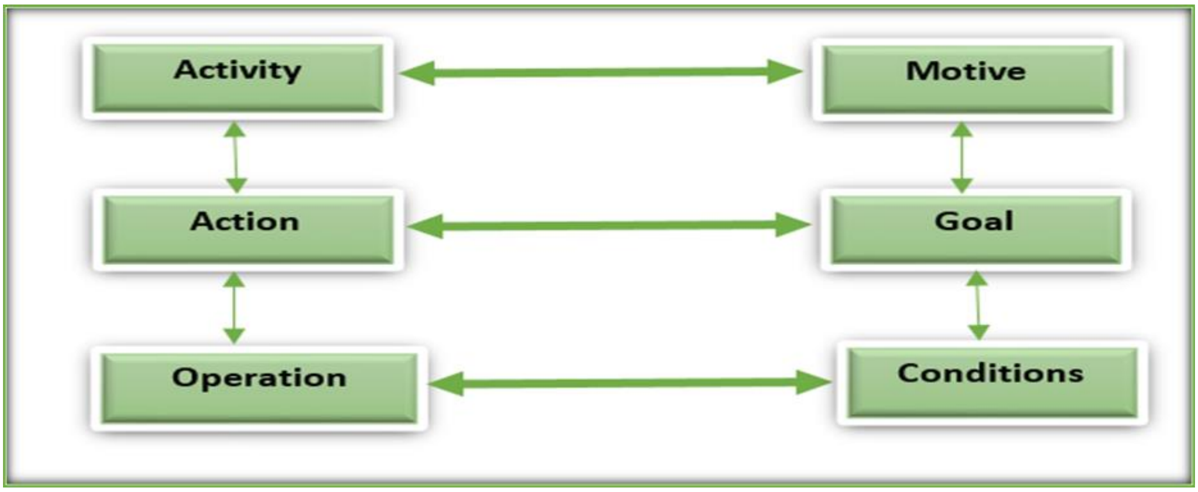

Figure 3: Leont'ev Hierarchical Activity Structure

[Adapted from: (Núñez, 2009, p. 3)]

However Engestrom argued that the model "failed to develop Vygotsky's model into one collective activity" (Engestrom, 1987, p. 78). Engestrom then proposed the third generation Activity Theory. Engestrom expanded on the second generation Activity Theory by adding rules, community and the division of labour as depicted in Figure 4.

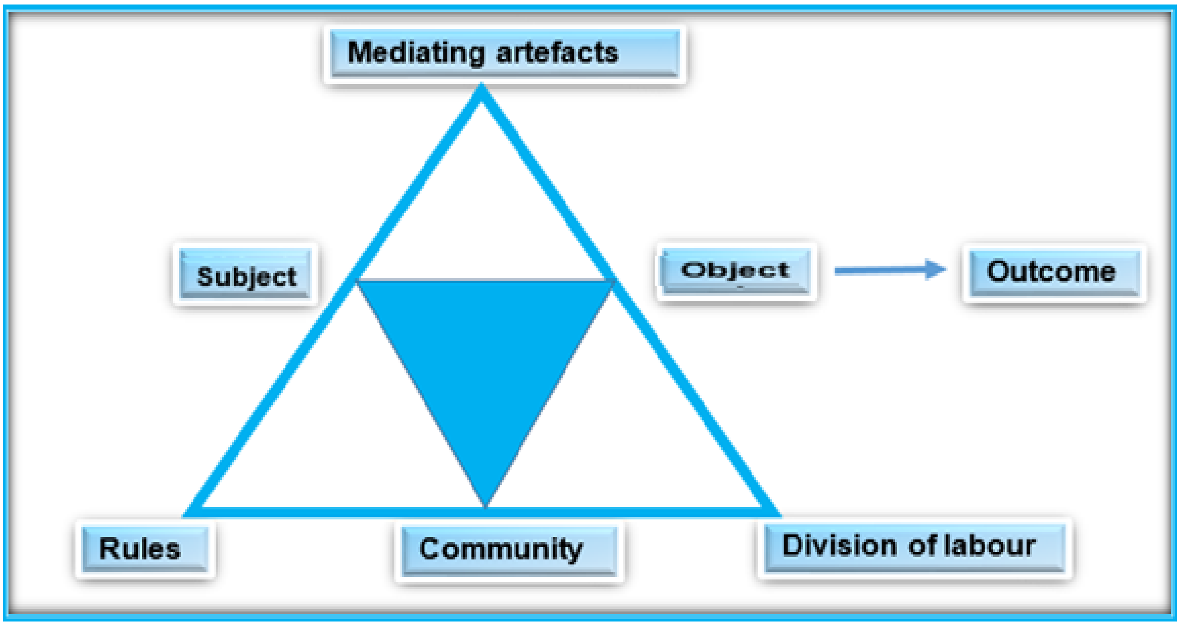

Figure 4: Third generation Activity Theory

[Adapted from: Engestrom, (1987)]

Hardman (2005, p. 3) explains that:

- The subject can be described as an individual who is the focus of the study.
- The mediating artefacts are the "tools that the subject uses to act on the object space".
- The object "refers to the raw material or problem space at which the activity is directed".
- The communities in the study refer to all the stakeholders involved in the community.
- The rules are the norms that determine the subject's action.
- The division of labour refers to the delegation of "responsibilities, tasks and power relations within a classroom as well as throughout the school".

2.6.2 Application of Activity Theory in the current study

Activity Theory in this study provided the "framework for describing the structure, development and context for the activities" (Hardman, 2005, p. 3) that was supported by computers. This study is based on the principles of the first generation Activity Theory. Activity Theory provides a suitable lens for the study on the teachers' ICT integration in the mathematics classroom. Using the underlying principles of Activity Theory this study focuses on the interaction between the mathematics teacher, the mathematical performance of learners and the use of computers in the classroom. Vygotsky's Activity Model relates to the current study in the following manner (See Figure 5):

- The mediating artefacts are represented by the computer in education in general.
- The subject is represented by the mathematics teachers who participated in the TIMSS 2011 study.
- The objective is that the mathematics teachers use computers for preparation, administration and for classroom instruction.

The outcome will be reached once the teachers fully integrate computers in all aspects of their classrooms (i.e. in preparation, administration and classroom instruction).

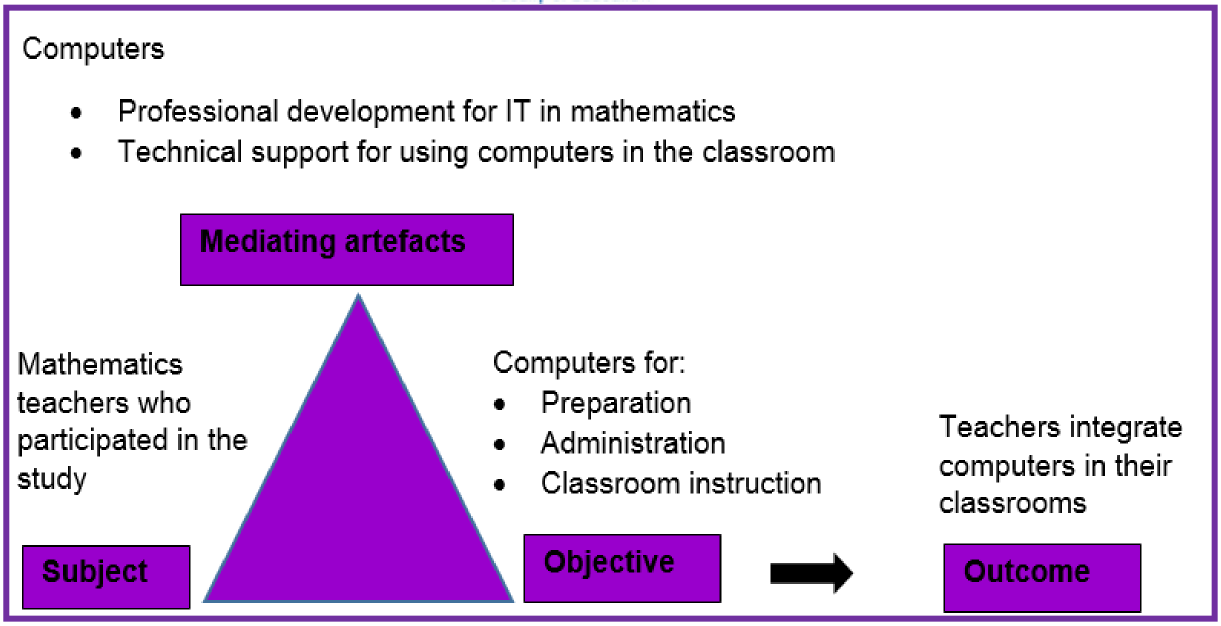

Figure 5: Third generation Activity Theory application the study

[Adapted from: Kuutti (1995)]

2.7 CONCLUSION

A large amount of research has been conducted on the integration of ICTs in mathematics (Agyei & Voogt, 2012; Ahmed & Osman, 2016). Researchers focused on barriers hindering ICT integration (Aslan & Zhu, 2016), the readiness of mathematics teachers (Howie & Blignaut, 2009), advantages and disadvantages of ICT (Huges, 2016), to name a few. Evidently, the lack of support was identified as the most disturbing barrier to ICT integration in mathematics (Uwaezuoke & Ekwueme, 2015). Most of the studies indicated that mathematics teachers did not use computers in their classrooms due to certain barriers (Ahmed & Osman, 2016; Mofokeng & Mji, 2010). The findings of Ahmed and Osman (2016) as well as Mofokeng and Mji (2010) stated that mathematics teachers did not use computers in their classrooms. However, the findings of Stols et al., (2015) differ from Ahmed and Osman (2016) as well as Mofokeng and Mji (2010) since they found that teachers were uncertain on how to use computers in their classrooms. One can assume that teachers who are not sure how to use computers in their classrooms lack skills (Kamau, 2014; Amuko et al., 2015) and confidence (Leendertz et al., 2013; Dotong et al., 2016). Other barriers to computer integration in mathematics emerged from the literature. For instance, Chigona et al., (2014) and Akkaya (2016) argued that large class sizes and the lack of ICT knowledge of learners prevent teachers from using

ICTs. The researcher concurs with Chigona et al., (2014) and Akkaya (2016), because even if teachers are competent and receive ample support from their institutions, large class sizes and the learners' lack of ICT knowledge can demotivate teachers to use computers in their lessons.

Literature on studies in South Africa regarding ICT integration mostly utilised case studies and retrieved data from SITES 2006 (Leendertz et al., 2013; Cassim, 2010). Studies that used TIMSS 2011 focused on the use of computers and the mathematics performance of learners (Visser, Juan & Feza, 2015). No recent studies were found on how South African mathematics teachers integrate computers in their classrooms. Therefore, the current study utilises TIMSS 2011 data to determine how mathematics teachers in South Africa are using computers. The study also investigates how mathematics teachers perceive support in integrating ICT and their involvement in professional development.

Chapter 2 dealt with literature relating to mathematics education, benefits of using computers in mathematics education, barriers to integration of computers in teaching and learning. Furthermore, previous studies internationally and nationally were also discussed. The theoretical framework of the study, Activity Theory, concluded this chapter. The next chapter will discuss the research design and methodology of this study.

CHAPTER 3

RESEARCH DESIGN AND METHODS

3.1 INTRODUCTION

Chapter 3 begins by outlining the philosophical worldview and research approach that frames the study. The data collection process and methods used for the TIMSS 2011 will then be summarised. Finally, the research design selected for the current study will be defined, with subsequent sections explaining the sampling and data collection. This chapter were guided by the main research question that focused on how South African mathematics teachers integrate computers into their classrooms. It was also lead by sub-questions about the purpose and extent of computer use, the support teachers get for integrating computers into their teaching activities and teachers' participation in professional development activities relating to the integration of IT into mathematics.

3.2 PHILOSOPHICAL WORLDVIEW AND RESEARCH APPROACH TO THE STUDY

Philosophical worldview can be described as the way in which the researcher interprets the world or the "general orientation" about how the researcher perceives the world (Creswell, 2009, p. 4). A worldview can be described as how one looks at the world, using the beliefs that guide an individual's life. A researcher's methodological preference is normally a rational outcome of their worldview or ontological and epistemological assumptions (Hitchcock & Hughes, 1995). The philosophical worldview adopted in this study is explained in the subsequent sections.

3.2.1 Ontology

Ontology can be described as what the researcher believes is real (Howell, 2013; Sefotho, 2015). In this study, the principles of critical realism are employed. A critical realist believes that "reality exist independent of humanity but cannot be perfectly apprehended" (Howell , 2013, p. 219). The researcher also assumes that reality is objectively given and is measurable using properties which are independent of the researcher and his or her instruments; in other words knowledge is objective and quantifiable.

3.2.2 Post-positivism

The philosophical worldview adopted in the study is post-positivism. Howell (2013) explains that post-positivism was developed through positivism. Post-positivist researchers "hold a deterministic philosophy" (Creswell, 2009, p. 5). Post-positivism includes falsification, a concept that was developed by Karl Popper who believed that if theories are not "falsifiable then they are not scientific" (Popper, 2002, p. 54).

The researcher employed the ontological assumptions of post-positivism to analyse how South African mathematics teachers are integrating computers in their classrooms. These assumptions include the following:

- The absolute truth can never be found (Millan, 2012). If a researcher can never find the absolute truth, it indicates that the findings will in most cases be imperfect. Based on this assumption researchers reject hypotheses instead of proving it (Phillips & Burbules, 2000). This study is a secondary data analysis (SDA), meaning the researcher did not collect the data. Consequently, the flaws of the data collection are unknown. Therefore, the researcher acknowledges that the findings will not be perfect.
- When conducting a study, researchers make claims that they continue to filter for claims that are more defensible (Schoenfeld, 2008). Quantitative researchers for instance Phillips and Burbules (2000) started with a theory which they based their study on. In this study, the researcher employed the principles of the first generation Activity Theory which in this case focused on the interaction between the mathematics teacher, the mathematics performance of learners and the use of computers in the classroom.
- The information provided by the participants (Creswell, 2009), or the observations from the researcher form the knowledge of the study (Phillips & Burbules, 2000). In this study, the researcher utilised the data from the IEA data repository. The data were collected from the Grade nine mathematics teachers who participated in the TIMSS 2011 study.
- Researchers develop research questions, or hypotheses, which explain the situation of concern (Furragia, Petrisor, Farrokhyar & Bhandari, 2010). The

research question that guided the study is; How do South African mathematics teachers integrate computers in their classrooms? Three sub-research questions were derived from the primary research question namely:

1. For what purpose, and to what extent, do mathematics teachers use computers in their profession?
2. How do the mathematics teachers perceive the support they get for integrating computers in their teaching activities?
3. Have these teachers recently participated in professional development in integrating IT into mathematics?

- Being objective is a crucial element of post-positivism (Drew, Mullins & Osmond, 2009). A researcher should therefore carefully examine methods used in the study (Creswell, 2009). It is also vital that the researcher examine the conclusion to eliminate bias (Phillips & Burbules, 2000). For the purpose of this study, the researcher scrutinised the methods utilised by TIMSS 2011. The methods and procedures made available by Martin and Mullis (2012) are available on the TIMSS and PIRLS website. The editors included documents such as Sampling_Design.pdf and TIMSS 2011 Assessment Design, which assisted the researcher during the examination of the methods employed by TIMSS 2011.

3.2.3 Epistemology

The investigation into the theory and study of knowledge is called epistemology (Guba, 1990). Epistemological assumptions are concerned with how one can create, acquire and communicate knowledge; in other words, what it means to know (Guba & Lincoln, 1994). In this study, the position of objectivism was followed to ensure that a “bias free non-interference perspective can be reached” (Howell , 2013, p. 222).

3.2.4 Methodology

Sefotho (2015) writes that methodology is an approach which explains how the researcher intends to proceed with the study. Sefotho (2015), therefore, argues that it is “concerned with why, what, from where, when and how data was collected and analysed” (Sefotho, 2015, p. 9). Additionally, it can also be an attempt on “how the inquirer went about finding out whatever he or she believes can be known” (Guba and Lincoln, 1994, p. 107). Multiple methods of data analysis were employed to determine how South African mathematics teachers were integrating computers in their classrooms. These methods will be discussed in more detail in Section 3.5.6.

3.3 RESEARCH APPROACH

The research approach applicable to the study is quantitative by nature. Quantitative research is defined as a “process that is systematic and objective in its ways of using numerical data from a population to generalise the findings” (Maree, 2012, p. 145). This approach is applicable to the current study since it intends to make use of numerical data from a large population that will enable the generalisation of the findings.

3.4 RESEARCH DESIGN

A research design can be described as the strategy, or action plan, that the researcher uses to seek the answers to research problem (Kumar, 2011). This action plan includes everything to complete the study (Kerlinger, 1986). This SDA utilises the dataset of the TIMSS 2011 study. Firstly, the research design and methods of TIMSS 2011 will be discussed. Thereafter, an explanation on the methods used in the current study follows.

3.4.1 Research design of TIMSS 2011

TIMSS 2011 followed a quantitative research design (Martin & Mullis, 2012). TIMSS 2011 was an international study, which assessed the mathematics and science knowledge of Grade eight learners in 45 countries (Prinsloo & Rogers, 2013). TIMSS 2011 is the fifth study of its kind since the commencement of TIMSS in 1995 (Kasberg, Roey, Ferraro, Lemanski & Erberber, 2013). TIMSS is an international study that measures the mathematics and science competencies of Grade four and eight learners, worldwide (Kilic & Askin, 2013). As mentioned in Chapter 1, South Africa, together with Botswana and Honduras, administered the assessment to their Grade nine learners instead of their Grade eight learners (Prinsloo & Rogers, 2013). South Africa used their Grade nine learners because their Grade nine curriculum is on par with the level of the Grade eight assessment of TIMSS (Reddy et al., 2015). TIMSS provides participating countries the opportunity to compare the mathematics and science achievement of fourth and eighth graders (Kaur, Areepattamannil &

Leong, 2013). The countries could decide whether they want to participate in the Grade four and eight/nine assessment, the Grade eight/nine assessment, or both (Foy et al., 2013a). In total, 608 641 students, 49 429 teachers, 19 612 principals and the NRC's of each country participated in TIMSS 2011 (Foy et al., 2013).

The IEA used a longitudinal survey, which means that data were gathered over a period of time (1995, 1999, 2003, 2007 and 2011) (Kilic & Askin, 2013). South Africa tested both Grade eights and nines in TIMSS 2002, "to investigate whether the sequence of topics taught would make a difference" (Reddy, 2006, p. 72). In contrast, researchers such as Spaull and Kotze (2015) are of the opinion that South Africa assessed both grades because, "earlier rounds of TIMSS indicated that the international Grade eight test was too difficult for South African students, and consequently too many students were performing at guessing level on the multiple choice questions" (Spaull & Kotze, 2015, p. 15). South Africa did not participate in the TIMSS 2007 assessment because of interventions and initiatives that were introduced by the education ministry at the time. The interventions placed strain on the Department of Education (DoE) as well as the educators (Reddy, 2006). It was then decided that South Africa should rather participate in the 2011 assessment in order for the "intervention programs to get embedded within the education system" (Reddy, 2006, p. 120).

3.4.2 Population and sampling of TIMSS 2011

The term population can be defined as a set of people with certain characteristics or a pool of items which is under consideration for a specific study (Pilot & Hungler, 1999). TIMSS 2011 had two target populations namely, Grade four and Grade eight learners (Prinsloo & Rogers, 2013). These populations are defined as follows:

- Population 1: Refers to all the learners "enrolled in the grade that represents four years of schooling counting from the first year of basic education" (Joncas & Foy, 2012, p. 4)
- Population 2: Refers to all the learners "enrolled in the grade that represents eight years of schooling counting from the first year of basic education" (Joncas & Foy, 2012, p. 4).

It is assumed that the learners from Population 1 and Population 2 will be aged between 9 and 10 years and between 13 and 14 years, respectively. However, all fourth and eighth graders were eligible to participate in the study irrespective of their age (Joncas & Foy, 2012). For this study only Population 2, the Grade nine mathematics learners of South Africa was considered. This population consisted of 9 504 schools and 988 632 Grade nine learners (Akih, 2015).

Sampling can be defined as a subdivision of a population that represents the main interest of the study; therefore it involves the process of selecting who will participate in the study (Koma, 2016). Countries had to meet the precision requirements of a minimum of 150 schools and a minimum of 4 000 learners per target grade (Joncas & Foy, 2012). Furthermore, a school participation rate of 85% from original sampled schools was required (Martin & Mullis, 2012). In addition, a classroom participation rate of 95% and a learner participation rate of 85% were required from the original school including the replacement school (Joncas & Foy, 2012).

In 2011, the IEA gathered information from 45 countries where mathematics and science are offered to learners in Grade eight (Martin & Mullis, 2012) and in Grade nine, as mentioned above. Stratified sampling was used, meaning that the "schools in the target population were arranged into groups or strata, that share common characteristics for example school type" (Joncas & Foy, 2012, p. 9). During the first sampling stage (sampling of schools), the NRCs of each country provided Statistics Canada with a list of schools, also called the sample frame (Martin & Mullis, 2012). The sample frame was then stratified, for example, in the case of South Africa, schools were sorted based on province, the language of teaching and the type of school (Public, Private and Dinaledi schools) (Visser et al., 2015). Statistics Canada, with the help of IEA DPC, made use of systematic random sampling to sample each school together with a replacement school (Martin & Mullis, 2012). Replacement schools were sampled just in case an original sample school refused to participate in the study (Martin & Mullis, 2012). At the second stage, the NRCs of each country made use of "With-in school Sampling software (Win W3S)" to randomly select classes from the sampled schools (Johansone, 2012, p. 5). If the sampled school agreed to participate, the NRCs requested the number of mathematics classes and teachers and captured the information in the Win W3S database (Martin & Mullis, 2012).

In the case of South Africa, a total 11 969 Grade nine learners from 298 schools participated in the TIMSS 2011 study. Reddy et al., (2015) explained that the reason for changing the testing grade from Grade eight to Grade nine, was because of the country's low performance in the previous TIMSS assessments. As mentioned in Section 3.4.1, the change was made to "enable a better match between the content knowledge presented to learners TIMSS and the curriculum coverage in South Africa" (Reddy et al., 2015, p. 3).

3.4.3 Data collection and instruments of TIMSS 2011

Countries located in the southern hemisphere, which included South Africa, were expected to collect the data in October and the countries situated in the northern hemisphere in May (Reddy et al., 2015). The data for TIMSS 2011 were collected through paper-and-pencil assessments (Kasberg et al., 2013). The TIMSS 2011 student, teacher, school and curriculum questionnaires were developed by the Staff members of TIMSS and PIRLS International Study Center at Boston College (Mullis, Drucker, Preuschoff, Arora & Stanco, 2012) and representatives of participating countries as a cooperative effort (Kasberg et al., 2013). The TIMSS 2011 assessment booklet consisted of two parts (mathematics and science) as well as the student questionnaire that was attached at the back of the booklet (Martin & Mullis, 2012). The assessment consisted of 28 item blocks (14 mathematics and 14 science) (Assesment Design TIMSS 2011 Chapter 4, 2012). For the TIMSS 2011 assessment eight mathematics, as well as eight science blocks from the previous assessment (TIMSS 2007), were included (Johansone, 2012). The remaining 12 blocks from TIMSS 2007 were then made available for public use; consequently 12 new blocks were designed for TIMSS 2011 (Assesment Design TIMSS 2011 Chapter 4, 2012). It was then decided that each block should appear in two booklets to link the booklets (Mullis et al., 2012) while keeping the booklets to a minimum (Assesment Design TIMSS 2011 Chapter 4, 2012). TIMSS 2011 finally used a matrix sampling approach, whereby the pool of mathematics and science items was packaged into a group of 14 booklets (Visser et al., 2015).

Strictly randomised and automated procedures were used to decide which school gets which booklet. Using Windows Data Entry Manager (WinDEM) in conjunction with Win W3S, a tracking form was produced for every school which, in advance, included details of all the learners sampled in each school with their unique identification (ID) numbers (Johansone, 2012). These details were produced and affixed in the form of a learner identity label on each booklet (Johansone, 2012). The HSRC pre-printed and pre-assigned batches of booklets (C.H. Prinsloo, personal communication, October 31, 2016). Thereafter these booklets were taken to schools allowing no deviation from the booklet assignment per learner (Johansone, 2012).

The same procedure was used for the booklet distribution among learners. Win W3S was used by the NRCs to assign a unique learner ID and booklets to each learner (Johansone, 2012). This was done for each school and each class. The software allocated a test booklet randomly to the first learner in each school, while factoring in the distribution across all schools (C.H. Prinsloo, personal communication, October 31, 2016). Each subsequent learner received the next booklet, for instance, learners 1-34 could get Booklets 04, 05, 06 etc. up to 14, then starting all over with 01 every time till every learner received a booklet (Johansone, 2012; C.H. Prinsloo, personal communication, October 31, 2016). The test administrator of each sampled class distributed the booklets to the learners in a systematic rotation so that each achievement block was assigned to an equal number of students (Johansone, 2012). Consequently all 14 booklets were used, sometimes two to six times, based on the size of the class. Each learner received only one booklet (Johansone, 2012) to minimize the burden of assessment (Assesment Design TIMSS 2011 Chapter 4, 2012). For the mathematics part of the assessment learners answered only a few (Winnaar, Frempong & Blignaut, 2015) of the 217 items (Kaur et al., 2013). The estimated time for the eighth graders to complete the assessment was 90 minutes, 45 minutes for each section (Mullis et al., 2012).

3.4.4 Data analysis

A statistical analysis package such as Statistical Package for the Social Sciences (SPSS) Version 23 was used for the data analysis (Liang, Zhang, Huang, Shi & Qiao, 2015). Additionally, the study utilised the International Database Analyser Software (Version 3.0) and the IEA-IDB Analyzer (Version 3.1.17) due to the complex sampling characteristics of TIMSS 2011 (Liang et al., 2015; Visser et al., 2015). The IEA-IDB Analyzer was created for data analysis of complex sample structures that included IEA surveys (Visser et al., 2015). The software was developed by "The IEA Data Processing and Research Center (IEA-DPRC)" (Liang et al., 2015, p. 4). The IEA made use of the Jackknife Replication method which is a "cross-validation technique to estimate the bias of an estimator, it also includes variance estimation" (Abdi & Williams, 2010, p. 1). The method includes "appropriate sampling weights and replicate weights" (Liang et al., 2015, p. 4) to "estimate the standard error" (Afana, Lietz & Tobin, 2013). The "standard error is a measure of the variability due to sampling when estimating a statistic, and is often included in reports containing estimates from survey data" (Kasberg et al., 2013, p. 79).

Item Response Theory (IRT) methods were used to assign learner scores (Visser et al., 2015). IRT methods were also used for the creation of five "plausible values for each learner" (Winnaar et al., 2015, p. 135). The achievement scores were calculated out of a possible 1 000 scale points with a mean of 500 and standard deviation of 100" (Visser et al., 2015, p. 2). The mean (500) as well as the standard deviation (100) was fixed from the commencement of the TIMSS study, in order for participating countries to compare their learners' achievement over a period of time (Prinsloo & Rogers, 2013; Reddy et al., 2015).

3.4.5 Quality control

The IEA applied rigorous measures for quality control to ensure high quality data collection and processing (Laubscher, 2013). The NRCs received manuals to translate and/or adapt questionnaires to their local situations. As mentioned in Chapter 1, all NRC's and their staff received "training in constructed-response item scoring and data management" (Johansone, 2013, p. 3). They also received guidelines for all operational activities. In addition, International Quality Control Monitors (IQCMs) assured quality (Johansone, 2013). In order to ensure the quality of the TIMSS 2011 assessment, the IQCMs sampled 15 schools for close observation of the administration process and data collection (Johansone, 2013). The IQCMs were also tasked to note if any changes were made to the administration script, timing and procedures (Martin & Mullis, 2012). Furthermore they had to check whether the changes, if any, made by the international translation verifier were incorporated into the “final assessment instruments” (Johansone, 2012, p. 16).

3.4.6 Reliability

Cohen and Manion (1994) explain that reliability is the measure for the consistency of instruments. The NRCs used WinDEM software to ensure that the data were captured correctly (Johansone, 2012). Furthermore, countries could translate and/or make adaptions to the booklets as well as the questionnaires, therefore it was vital to evaluate each country’s translations (Johansone, 2012). NRCs had to submit their instruments to the IEA Secretariat for an independent translation verification (Martin & Mullis, 2012). Thereafter, the IEA Secretariat, with the assistance of various translators, had to evaluate every country’s translations and suggest changes to the translated instruments, if necessary (Martin & Mullis, 2012). Firstly, the verifiers had to check for “accuracy, linguistic correctness, comparability of the translation and adaptions” of the instruments (Yu & Ebbs, 2012, p. 11). Secondly, they had to document “any deviations that occurred between national and international versions including additions, deletions and mistranslations” (Yu & Ebbs, 2012, p. 11). Lastly, the verifiers had to make use of track changes in Microsoft Word, or Sticky Notes in Adobe PDF, to make suggestions on how to “improve the accurracy and comparability of the national instruments” (Yu & Ebbs, 2012, p. 11).

3.5 RESEARCH DESIGN AND METHODS OF THE CURRENT STUDY

This study utilised the TIMSS 2011 data as a basis for the research. As such, a SDA was used to explore the data collected by the IEA during TIMSS 2011. This study follows a quantitative research design, meaning that the researcher is “testing objective theories by examining the relationship among variables” (Creswell, 2009, p. 5).

3.5.1 Secondary data analysis (SDA)

SDA can be described as data that were previously collected, by another researcher(s), for a different purpose and to address a different research problem (Koziol & Athur, n.d.). Koziol and Athur (n.d.), McCaston (2005) as well as Smith et al., (2011) all agree that there are advantages in respect of SDA, as opposed to primary data collection. These are discussed in the paragraphs below.

Researchers with limited, or no funding, often choose SDA since there is little, or no cost involved (Smith et al., 2011). Koziol and Athur (n.d.) and Mouton (2001) argue that data collection can be expensive, especially if a researcher has to travel far to collect data from a large sample. By making use of secondary data, the researcher does not have to dedicate resources to data collection and in the process saves money. The researcher is also saving time (Koziol & Athur, n.d.) since the research design has been completed by the previous researcher(s) and duplicate research efforts can be avoided (Mouton, 2011).

Since the data collection process is already completed and the data have been cleaned, the researcher can dedicate more time to analysing the data (Boslaugh, 2007). The researcher also has access to international and cross-historical data that normally takes years to collect (Koziol & Athur, n.d.). For example, the TIMSS 2011 dataset consisted of 45 countries; therefore it contains large sample sizes, which makes generalisation possible. Large datasets include variables, which contain "considerable breadth" and "increase statistical precision" (Koziol and Athur, n.d. p. 9). Many novice researchers who choose to use secondary data therefore have access to high quality data, which were collected by more experienced researchers (Smith et al., 2011). Lastly, researchers can reanalyse their previous dataset in order to gain new ideas or generate new insights.

In contrast, researchers, such as Boslaugh (2007), highlights the following disadvantages of SDA. Since the data have been collected for a different purpose and research problem, the dataset may not answer the current research question. Another disadvantage is that the researcher does not have control over the content of the dataset since he/she did not collect it (Boslaugh, 2007). The variables may have been grouped differently than the current researcher would have preferred, for example race could have been grouped as Black, White and Other. The researcher may have preferred Black, White, Coloured, Indian/Asian and Other.

The researcher has to assume that the data collection was well done, since he/she did not collect the data themselves. (Cheng & Phillips, 2014). The researcher is, furthermore, restricted by the limitations of the dataset (Boslaugh, 2007). For example, to protect the anonymity and confidentiality of the participants, variables such as “ethnicity, names of the primary sampling unit, race, and specific age groups” could have been excluded (Cheng & Phillips, 2014 p. 1).

Another major disadvantage of SDA is that the researcher(s) who collected the data and the researcher(s) who intend to use the dataset are not the same (Smith et al., 2011). Data collection and study-glitches may be unknown to the intended researcher(s) (Tasic & Feruh, 2012). Furthermore, the supporting documentation of datasets may not be sufficient. Consequently, intended researchers might miss valuable details if documentation such as user guides, codebooks, and almanacs are not available for datasets (Koziol & Athur, n.d.; Cheng & Phillips, 2014).

3.5.2 Data collection of the current study

A SDA was conducted, drawing on South Africa’s data from the IEA study data repository for the TIMSS 2011 study. The researcher retrieved the Grade nine learners’ and their mathematics teachers’ dataset in SPSS format. Data were retrieved from a sample of 298 schools.

3.5.3 Instruments for collection of data

The researcher utilised the mathematics teacher questionnaire of TIMSS 2011. Table 4 shows the specific questions used in this study.

Table 4: TIMSS 2011 Questions used in this study

Question number	Questions (see attached questionnaire for full item text)
TQG-01	By the end of this school year, how many years will you have been teaching altogether?
TQG-02	Are you female or male?
TQG-03	How old are you?
TQG-05A	During your post-secondary education, was mathematics your major or main area of study?
TQG-05F	During your post-secondary education, was education mathematics your major or main area of study?
TQG-09AA	Do you use computers in your teaching for preparation?
TQG-09AB	Do you use computers in your teaching for administration?
TQG-09AC	Do you use computers in your teaching for classroom instruction?
TQG-09BA	How much do you agree that you feel comfortable using computers in your teaching?
TQG09BB	How much do you agree that when you have technical problems, you have ready access to computer support staff in your school?
TQG-09BC	How much do you agree that you receive adequate support to integrating computers in your teaching activities?
TQG-20D	When you teach mathematics to this class, how do you use computer software for mathematics instruction?
TQG-22CA	How often do you have the students explore mathematics principles and concepts on the computer?
TQG-22CB	How often do you have the students practice skills and procedures on the computer?
TQG-22CC	How often do you have students look up ideas and information on the computer?
TQG-22CD	How often do you have students process and analyse data on the computer?
TQG-29D	In the past two years, have you participated in professional development in integrating IT into mathematics?

[Note. Adapted from: (Foy et al., 2013b)]

3.5.4 Data preparation

This study made use of secondary data that were collected for a different purpose. Therefore, the researcher had to ensure that the methods and procedures that were used by TIMSS 2011 were understood. It was necessary to study the codebook, user guide and other documents that broadened the understanding of the TIMSS 2011 study (TIMSS 2011 International Database, 2012). The researcher used the codebook, which contained all the variables (variable name, description, and format) to select the variables suitable for the current study.

3.5.5 Data analysis of the current study

Data drawn from TIMSS 2011 were analysed using descriptive statistics as well as the Pearson two-way Chi-square cross tabulations. Descriptive statistics included determining measures such as percentages. Results were illustrated by means of pie charts and bar graphs. The Pearson two-way Chi-square cross tabulations were performed to test for dependency between the variables. A significance level of 5% (0.05) was used for all statistical tests. SPSS version 23, in conjunction with the International Database Analyzer Software (IDB) version 3.0, was used for the analysis.

Table 5 outlines the research questions, research design, data collection, data analysis, and sample of the study.

Table 5: Research design

No	Research questions	Research design	Data Collection	Data analysis	Sample
1	How do South African mathematics teachers integrate computers in their classrooms?	Quantitative design	SDA	Descriptive statistics and Pearson two-way Chi-square cross tabulations	Mathematics teachers from 298 schools in South Africa
2	For what purpose and to what extend do mathematics teachers use computers in their profession?				
3	How do the mathematics teachers perceive the support they get for integrating computers in their teaching activities?				
4	Have these teachers recently participated in professional development in integrating IT into mathematics?				

Table 6 outlines the variable name, field name, and statistical techniques of the study.

Table 6: Descriptive statistics

No	Variable name	Field name	Statistical techniques
1	Years of teaching	BTBG01	Pearson two-way Chi-square tabulations Pie chart Bar graph
2	Teacher's gender	BTBG02	
3	Teacher's age	BTBG03	
4	Teacher's major mathematics	BTBG05A	
5	Teacher's major education mathematics	BTBG05B	
6	Computers for preparation	BTBG09AA	
7	Computers for administration	BTBG09AB	
8	Computers for classroom instruction	BTBG09AC	
9	Comfortable using computers	BTBG09BA	
10	Adequate support	BTBG09BC	
11	Technical support	BTBG09BB	
12	Reasons for using computer software	BTBM20D	
13	Computers to explore concepts	BTBM22CA	
14	Computers to do procedures	BTBM22CB	
15	Computers to look up ideas	BTBM22CC	
16	Computers to process data	BTBM22CD	
17	Professional development for IT	BTBM29D	

3.5.6 Reliability and validity of the current study

Reliability and validity are two important concepts that needs to be considered in this study. These concepts are described in the subsequent sections.

3.5.6.1 Reliability

Reliability can be defined as the "extent to which a measuring instrument is repeatable and consistent" (Maree, 2012, p. 215). In addition (Leedy & Omrod, 2010) argue that reliability also "yields consistent information about the characteristic(s) being assessed" (p. 389). This is a SDA using data from TIMSS 2011. Consequently, the researcher relied on the measures put in place by the IEA to ensure reliability of their instruments. For example the IEA administers the TIMSS assessment every four years in a consistent manner (Johansone, 2012). This means standardised procedures are followed in each cycle. These measurements are discussed in Section 3.4.6.

3.5.6.2 Validity

Validity refers to the "extent to which an instrument measures what it is supposed to measure" (Maree, 2012, p. 216). There are two types of validity namely:

Internal validity (Credibility)

Leedy and Omrod (2010) explain that "internal validity of a research study has to do with the extent to which its design and data it yields allow the researcher to draw accurate conclusions about cause-and effect and other relationships within the data" (p.103). As mentioned earlier, the researcher had to rely on the quality assurance of TIMSS. TIMSS piloted a "full-scale field test of all instruments and operations procedures" (p. 2) before the actual data collection (Johansone, 2012). To ensure internal validity, the researcher produced credible findings that are substantial. In order to improve the credibility of the findings the researcher reported on positive as well as negative findings.

- **Content validity**

  Content validity can be described as "the extent to which the instrument covers the complete content of the particular construct that is set out to measure" (Maree, 2012, p. 217). The researcher did not design any instrument due to the SDA nature of the study. The IEA, however, employed experts in the field of mathematics for the TIMSS 2011 item writing process. Experts worked in pairs or sometimes groups consisting of three members. The item writing process was done according to strict guidelines to ensure content validity. For example, "timing, grade appropriateness, difficulty level, potential sources of bias and ease of translation" (Martin & Mullis, 2012, p. 2) had to be considered. Basically TIMSS 2011 ensured that the items in the assessment were covered by the curriculum of the participating countries. For instance, the TIMSS 2011 Grade Eight assessment was on par with the Grade Nine curriculum of South Africa. Therefore the Grade Nine learners of South Africa completed the assessment.

- **Construct validity**

  Leedy and Omrod (2010) describe construct validity as the "extent to which an instrument measures a characteristic that cannot be directly observed but is assumed to exist based on patterns in people's behaviour" (p. 115). TIMSS 2011 ensured construct validity by applying item analysis. For example a Science and Mathematics Item Review Committee (SMIRC) was established to identify and eliminate items that were too easy or too challenging. Only the items that were approved by the SMIRC were included in the field test which occurred from March to April 2010 (Martin & Mullis, 2012). The purpose of the field test was to collect evidence which ensured that the instrument measures what it is supposed to measure.

External validity (Generalisability)

On the other hand, external validity refers to the "extent to which the conclusions drawn can be generalized to other contexts" (Leedy & Omrod, 2010, p. 105). Furthermore, "generalisability is regarded as the way in which the reader is able to take the findings and transfer them to other contexts" (Maree, 2012, p. 306). The researcher provided characteristics of the mathematics teachers who participated in this study. For instance, analysis included the gender, age, teaching years experienced and the major of the mathematics teachers. To ensure transferability the setting is also included. For example, analysis was done, firstly with data of South Africa (Nationally), thereafter provincial analysis was conducted.

3.5.7 Ethical considerations

As with all studies undertaken by the IEA, TIMSS 2011 follows the international code of ethics as well as the national code of ethics as stipulated by each participating institution and/or country (Foy et al., 2013a). TIMSS 2011 assured the anonymity and confidentiality of all the learners, teachers and schools. TIMSS ensured that “all employees with access to the data signed affidavits of data confidentiality” (Kasberg et al., 2013, p. 125). Furthermore, “names of students, teachers and schools were removed by the field staff from the assessment booklets, the questionnaires and all other related materials and replaced with unique identification numbers” (Kasberg et al., 2013, p. 125). Throughout the study, the researcher adhered to the research ethics requirements of the University of Pretoria. The process included obtaining permission from the ethics committee of the institution and, in addition, getting approval from the HSRC, which was the NRC of South Africa. This was to ensure that the researcher used the data in a responsible, moral and professional manner, following the guidelines as stipulated by the University of Pretoria. Full anonymity and confidentiality was adhered to as no names of schools were disclosed in any aspect of the study.

3.5.8 Conclusion

In Chapter 3, the philosophical worldview of the researcher was discussed. Thereafter the research approach of the study was provided. This was followed by the research design of TIMSS 2011 as well as the current study. Furthermore, the ethical considerations of TIMSS 2011 and the current study were described. The next chapter will address the data analysis and interpretation of the results.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

This chapter explains the data analysis and the results of this study. The dataset was obtained from the IEAs data repository. The primary research question of this study is:

> How do South African mathematics teachers integrate computers in their classrooms?

Three secondary research questions are derived from the main question namely:

1. For what purpose and to what extent do South African mathematics teachers use computers in their profession?
2. How do the mathematics teachers perceive the support they get for integrating computers in their teaching activities?
3. Have these teachers recently participated in professional development in integrating IT into mathematics?

Before progressing to the analysis and interpretation of the data sampled, it is important to explain how the teachers who completed the TIMSS 2011 were selected to participate. Foy et al. (2013) stated that teachers were not sampled in the TIMSS 2011 assessment. The TIMSS 2011 user guide cautions that the analyses of teacher data should be made with students as the units of analysis. The user guide goes further to say that teacher data should be reported in terms of students who are taught by teachers with a specific attribute. In this chapter, respondents refer to learners who are taught by teachers with a specific attribute.

SPSS Version 23 in conjunction with the IDB-Analyzer version 3.2.21 were used to analyse the dataset. Descriptive statistics included percentages that were illustrated with pie charts and bar graphs. Additionally, the Pearson two-way Chi-square test was also utilised. Due to the amount of pages, all the outputs (in the form of an Addendum) of SPSS will be available on a Compact Disk (CD). Since there are almost 200 tables in the Addendum A, only the most interesting facts are discussed and only the most relevant graphs have been constructed; these findings and figures are given below. However, at each discussion the Addendum number is given for the interested reader who would like to view more detailed information. In this chapter, the Pearson two-way Chi-square test will be referred to as Chi-square for brevity. A 5% level of significance was used, meaning that the p-values were compared to 0.05. If the p-value was less than 0.05, the two factors were declared to be dependent. On the other hand, if the p-value was greater than 0.05 the two factors were declared to be independent. All p-values were reported up to three decimal places. Although all p-values were given, only p-values less than 0.05 were reported on.

This chapter is structured as follows. The teacher demographics are described in Section 4.2 in order to have a clear understanding of the characteristics of the respondents. Following this, the purpose and the extent of the mathematics teachers' computer integration is described in Section 4.3. Thereafter, in Section 4.4, the perceptions of mathematics teachers regarding support will be discussed. This chapter is concluded with a discussion on the professional development for integrating IT into mathematics followed by a summary of the findings. Note that the term 'mathematics teacher' has been shortened to 'teacher' in this chapter for conciseness in the write-up of the statistical analyses.

4.2 TEACHER DEMOGRAPHICS

4.2.1 Teaching experience of respondents

Figure 6 summarises the teaching experience of the teachers who participated in the study. The majority of respondents had between 10 and 19 years (32.7%) teaching experience. Overall 62.7% of respondents had a minimum of 10 years teaching experience (see Figure 6).

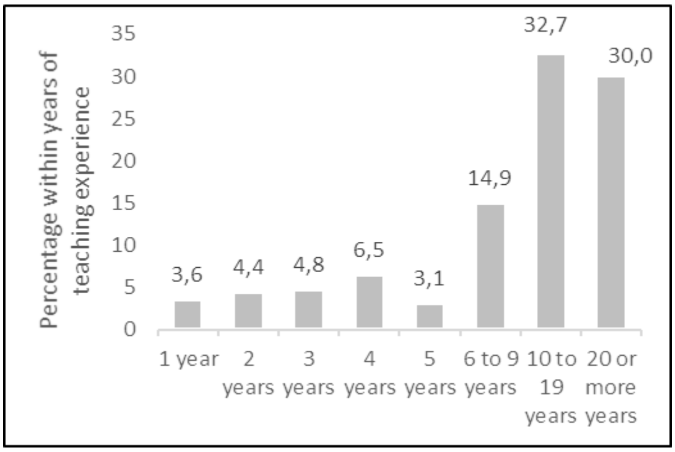

Figure 6: Teaching experience in years

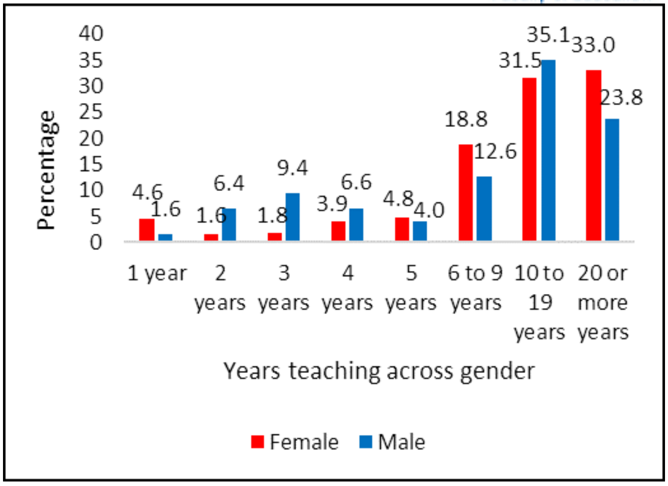

Figure 7: Teaching experience per gender

When focusing on the category with the highest percentage in Figure 6, i.e. the teachers with 10 to 19 years teaching experience, it can be seen from Addendum A3.2 that the majority of respondents fall in the age category 40 to 49 years (48.2%). Figure 7 is an illustration of the teaching experience across gender. Again focussing on the category with the highest percentage in Figure 6, i.e. the teachers with 10 to 19 years teaching experience, it can be seen, from Figure 7, that the majority of respondents were male (35.1%).

Turning our focus to the category with the lowest percentage in Figure 6, teachers with five years teaching experience (3.1%) were in the minority. Furthermore, very few teachers with one year teaching experience (3.6%) participated in this study; only 319 teachers fell in this category. Also, for this category of one year teaching experience, it can be seen from Figure 7 that the majority of respondents are female (4.6%) and between 25 and 29 years of age (14.8%); see Addendum A3.2.

Returning our focus to the category with the highest percentage in Figure 6, i.e. the teachers with 10 to 19 years teaching experience, it can be seen that the majority of respondents were from the Free State (48.4%); see Figure 8. On the contrary, it can be seen from Figure 8 that no teachers, with only one year teaching experience, were from the Eastern Cape, Free State, Northern Cape and the North West Provinces. In fact, the majority of this category, i.e. teachers with one year experience who participated in this study, were from the Western Cape (6.1%); see Figure 8 and Addendum A2.2.

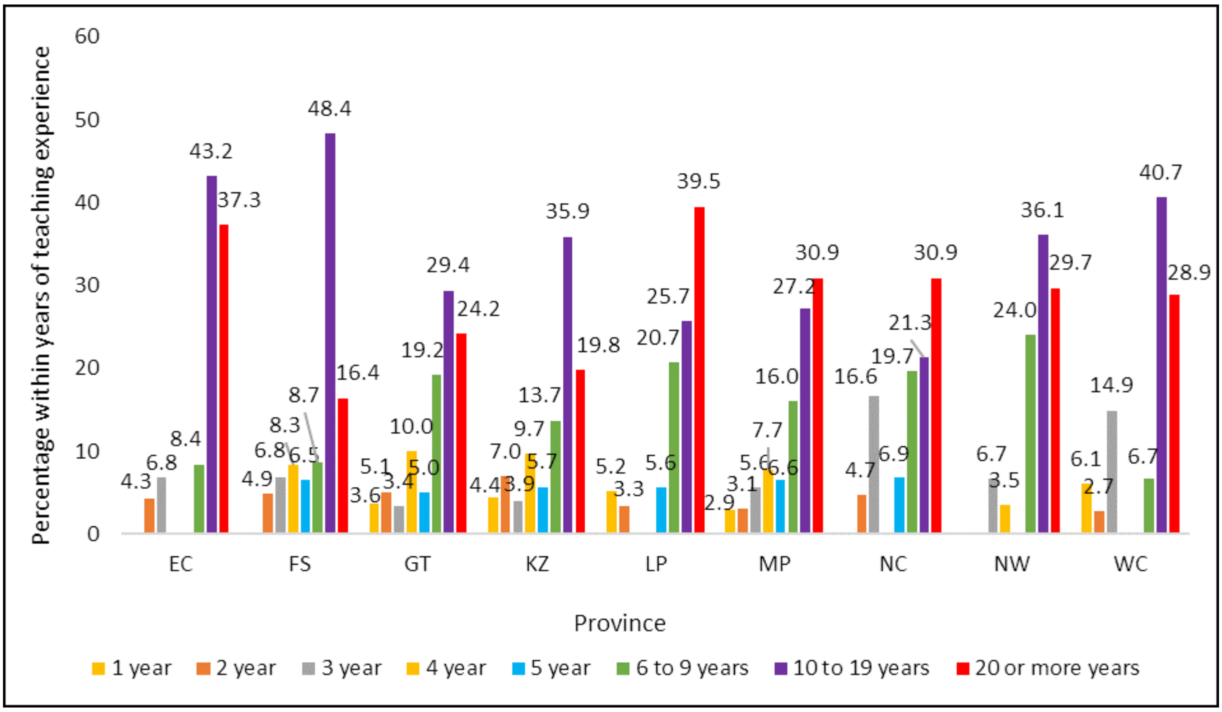

Figure 8: Teaching years per province

4.2.2 Gender of respondents

Figure 9 illustrates the gender distribution of the respondents. The majority of respondents were male (57.8%) which, of course meant that the minority were female (42.2%). When considering gender in combination with age categories, there were more males (86.1%) than females (13.9%) in the under 25 years of age category as well as in the 25 to 29 years of age category (62.6% male vs. 37.4% female); see Addendum A4.2. For the majority of the provinces the males outnumbered the females; see, for example, the Eastern Cape where the gender distribution is 69.9% male and only 30.1% female (see Figure 10 and Addendum A9.2). The North West and the Northern Cape were the only two provinces where the females outnumbered the males; from Figure 10 it can be seen that the percentages, for females, are 56.5% and 51.2% for the North West and the Northern Cape provinces, respectively.

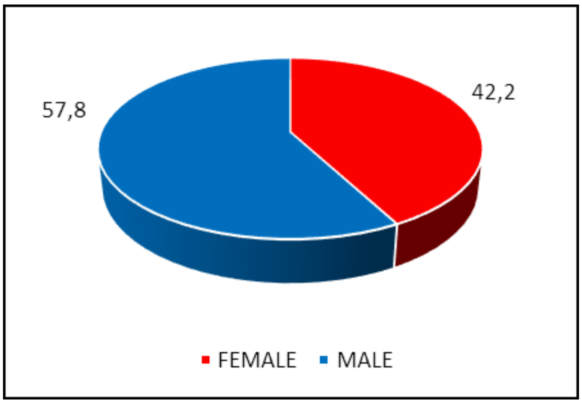

Figure 9: Gender distribution

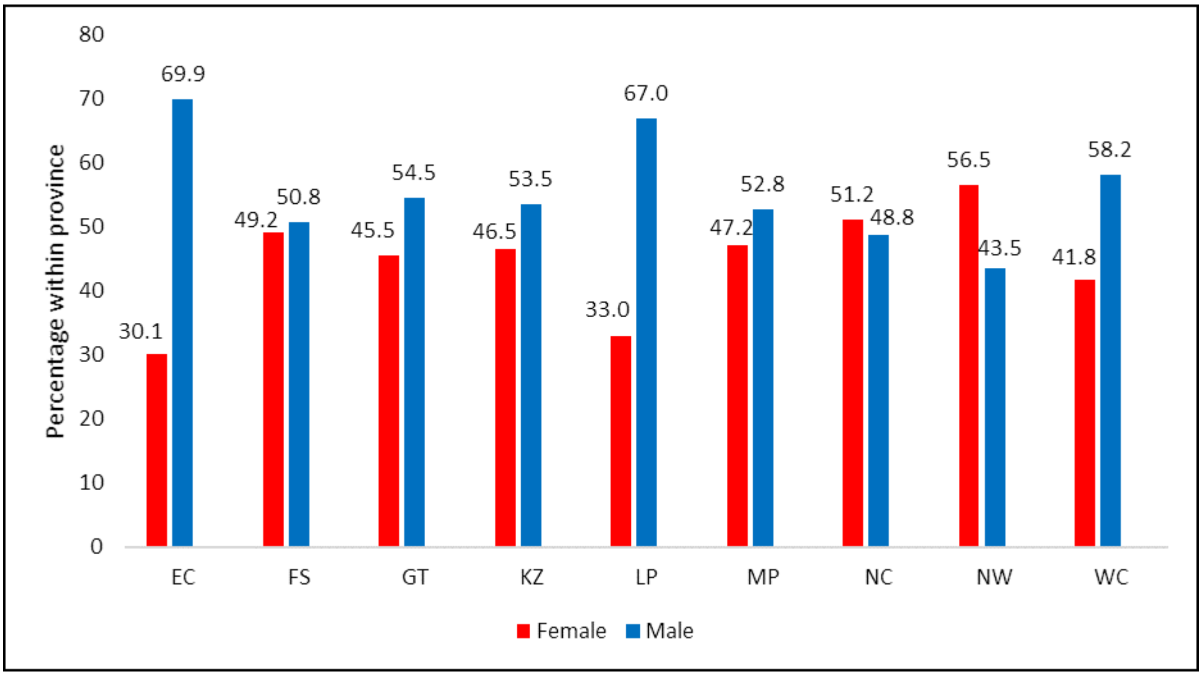

Figure 10: Gender distribution per province

4.2.3 Age groups of respondents

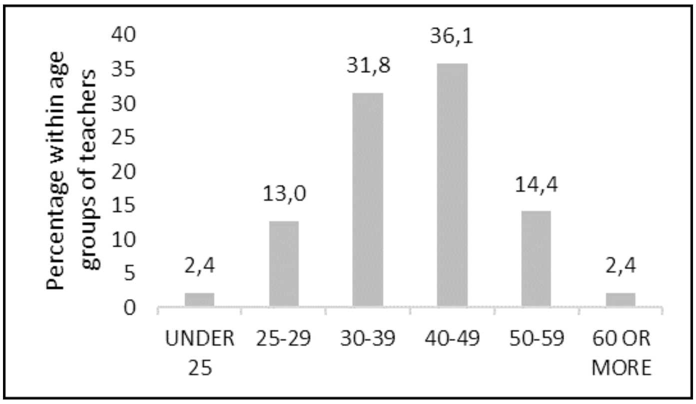

Figure 11: Age groups

Figure 11 is an illustration of the different age groups of the respondents. Overall, 36.1% of the respondents were between 40 and 49 years (36.1%) of age, whereas the minority were under the age of 25 years (2.4%); see Figure 11. It would be interesting to compare the TIMSS 2011 results with the actual number of teachers appointed in the system. Therefore, further research may be needed to find out why the age group under 25 is so under-represented. Results also revealed that very few respondents older than 60 years of age (only 2.4%). It could be an outcome of the fact that most South African teachers typically retire from the education sector around 60 years of age. Figure 12 shows the distribution of the various age groups per province. The majority of the respondents from the Eastern Cape, Free State, KwaZulu-Natal, Limpopo, Mpumalanga and Northern Cape were between 40 and 49 years of age.

Figure 12 also shows that there were no respondents older than 60 years from the KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape, North West and Western Cape. Surprisingly, no teachers under 25 years of age, from the Eastern Cape, North West and Gauteng Provinces, participated in the study (as illustrated in Figure 12).

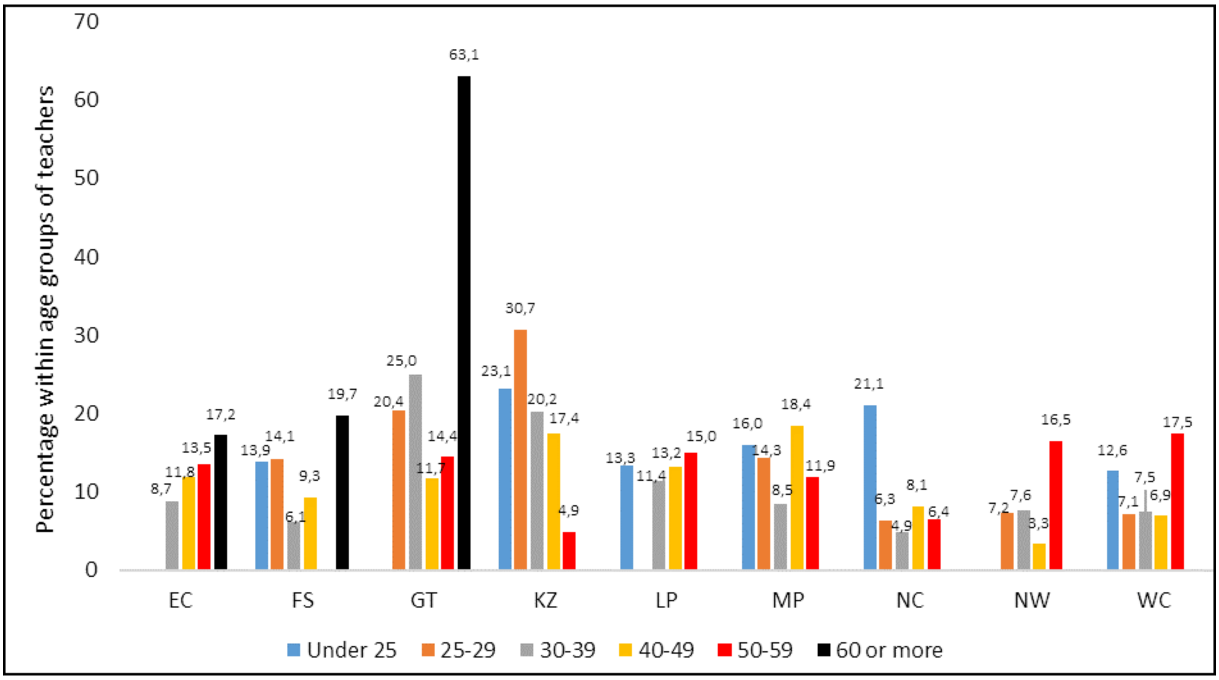

Figure 12: Age groups per province

4.2.4 Mathematics and education-mathematics as major

In the questionnaire the teachers were asked to indicate their major area of study. They could select more than one major from modules namely, "mathematics, biology, physics, chemistry, earth science, education-mathematics, education-science, and education-general" (Foy et al., 2013a, p. 139). Teachers could also state other majors if their major was not listed. For this study only mathematics and education mathematics as majors were included. TIMSS 2011 did not provide definitions of mathematics and education-mathematics which could have confused teachers. Consequently, the data may not be completely reliable. To avoid misinterpretation TIMSS studies should consider attaching a list of definitions to the questionnaires in the future.

In total, 81.7% of the respondents majored in mathematics (see Figure 13). All the respondents under 25 years of age (100%) across all provinces, majored in mathematics (see Addendum A12.2). This seems to indicate that it is compulsory nowadays for students to take mathematics as major, if they intend to teach the subject at school.

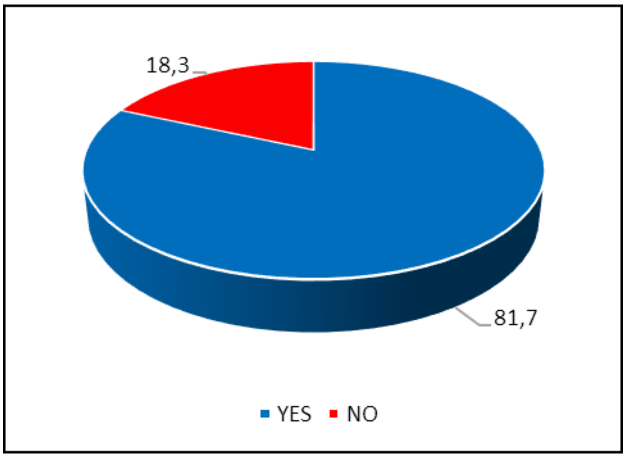

Figure 13: Mathematics as major

Results also revealed that the gender distribution for having mathematics as major is almost equal with 80.3% of males and 79.9% of females answering yes to having mathematics as a major, respectively (see Addendum A13.2).

When considering the provinces, Limpopo (92.3%) and KwaZulu-Natal (90.0%) are the two provinces with the highest percentage of teachers majoring in mathematics (see Figure 14 and Addendum 11.2).

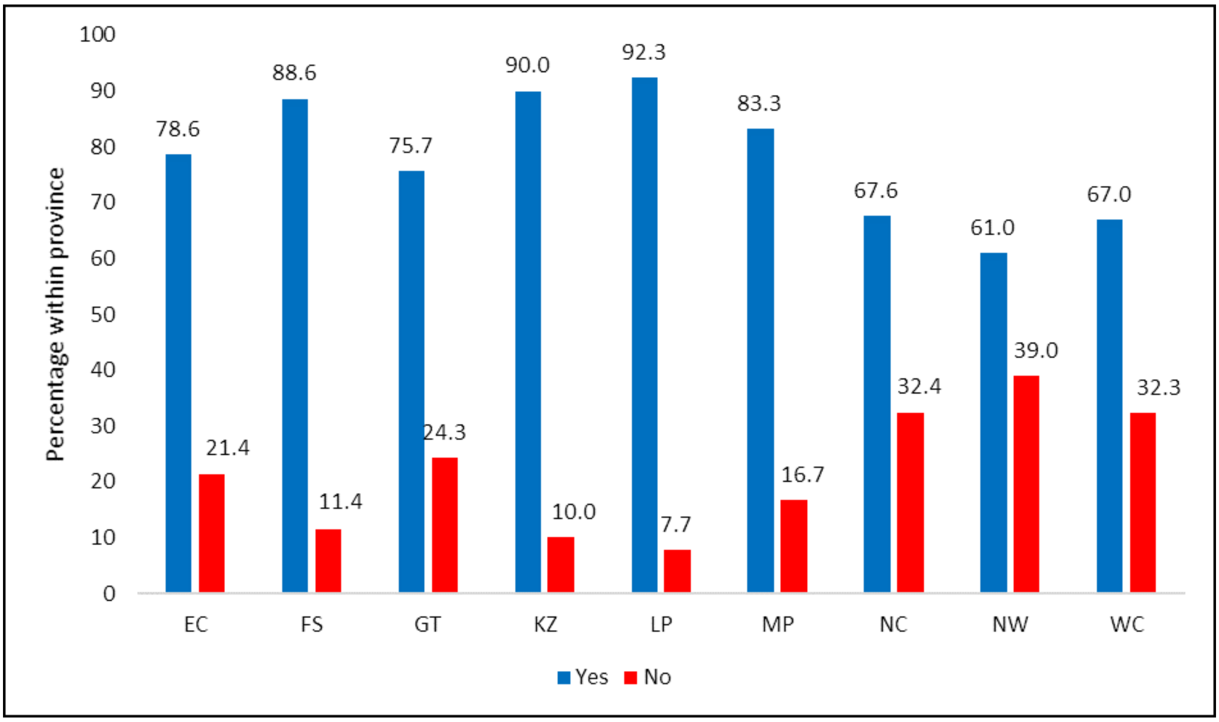

Figure 14: Mathematics as major per province

As illustrated in Figure 15, 36.3% of the respondents indicated that they specialised in education mathematics leaving 63.7% of respondents not majoring in mathematics education. When considering the provinces, North West (55.2%) and Free State (51.2%) are the two provinces with the highest percentage of respondents majoring in education mathematics (see Figure 16). Moreover, it seems as if more males (40.9%) than females (36.2%) specialised in education-mathematics (see Addendum A17.2).

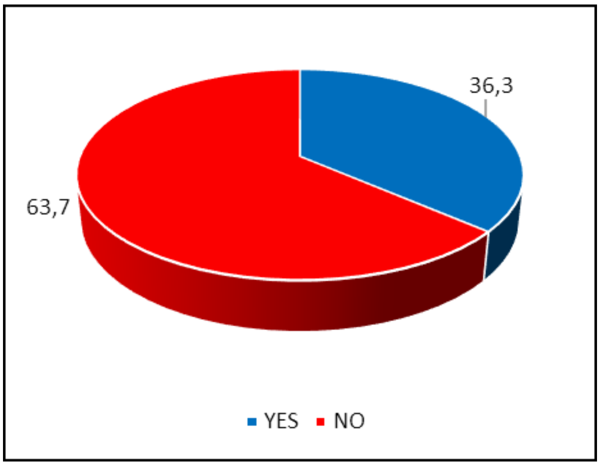

Figure 15: Education mathematics as major

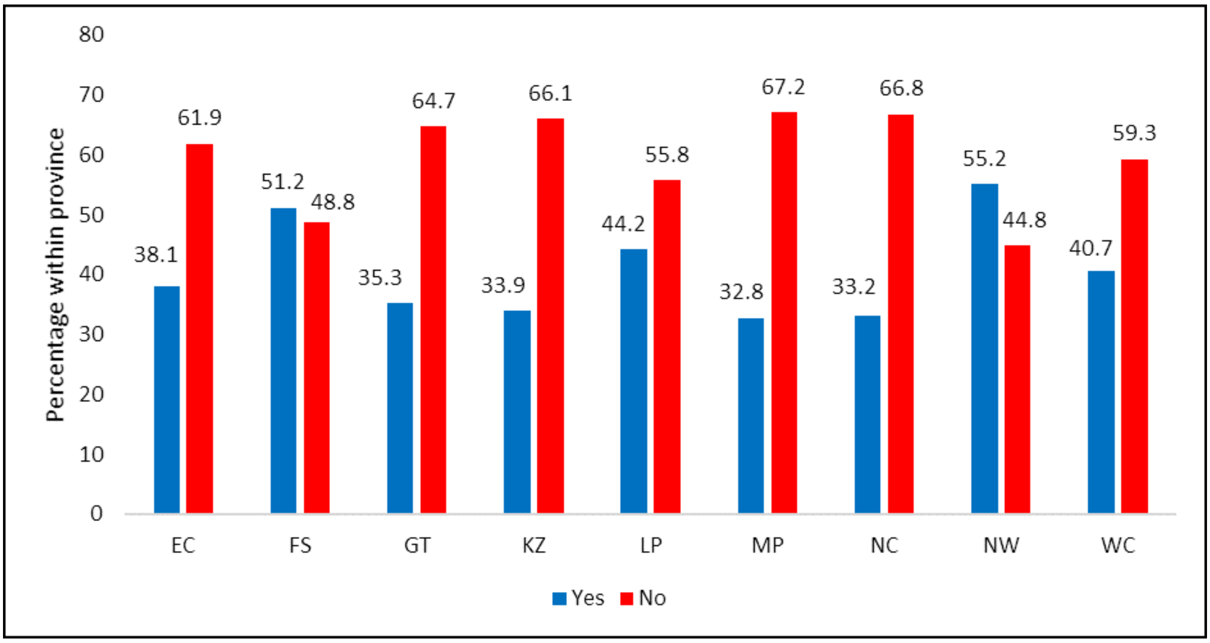

Figure 16: Education mathematics as major per province

4.3 PURPOSE AND EXTENT OF COMPUTER INTEGRATION

Results revealed that South African teachers use computers for preparation, administration and classroom instruction. These teachers typically use computers to explore concepts, to do procedures, to look up ideas and to process data. A more detailed explanation of the analyses are described in Sections 4.3.1 to 4.3.8.

4.3.1 Computers for preparation

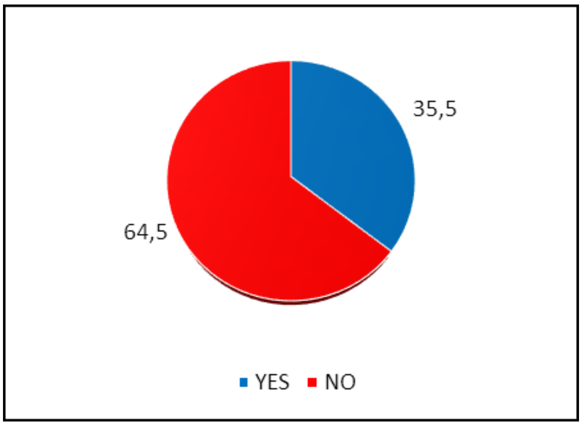

Figure 17: Computers for preparation

Figure 17 illustrates the use of computers for preparation. It shows that only 35.5% of respondents use computers for preparation. On the other hand, 64.5% of respondents do not use computers for preparation purposes.

Gender

The gender distribution of making use of computers for preparation is almost equal, which can be seen from Figure 18. The fact that making use of computers for preparation is not dependent on gender is iterated in Table 7 where the Chi-square p-value equals 0.210 (which is greater than 0.05) indicating independence.

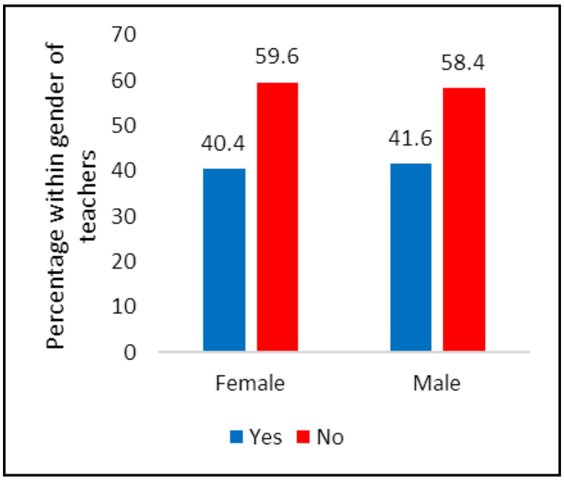

Figure 18: Computer preparation per gender

Age

From Figure 19 it can be seen that it is mostly the under 25 years of age (58.8%) and the 25 to 29 years of age (54.8%) respondents who make use of computers for preparation. On the other hand it seems that 65.0% of the respondents, who fall in the age group 40 to 49 years of age (are reluctant to integrate computers into their preparation activities (see Figure 19). There is also an association between the teachers who prepare for their lessons using computers and their age, since the p-value is less than 0.001 (see Table 7).

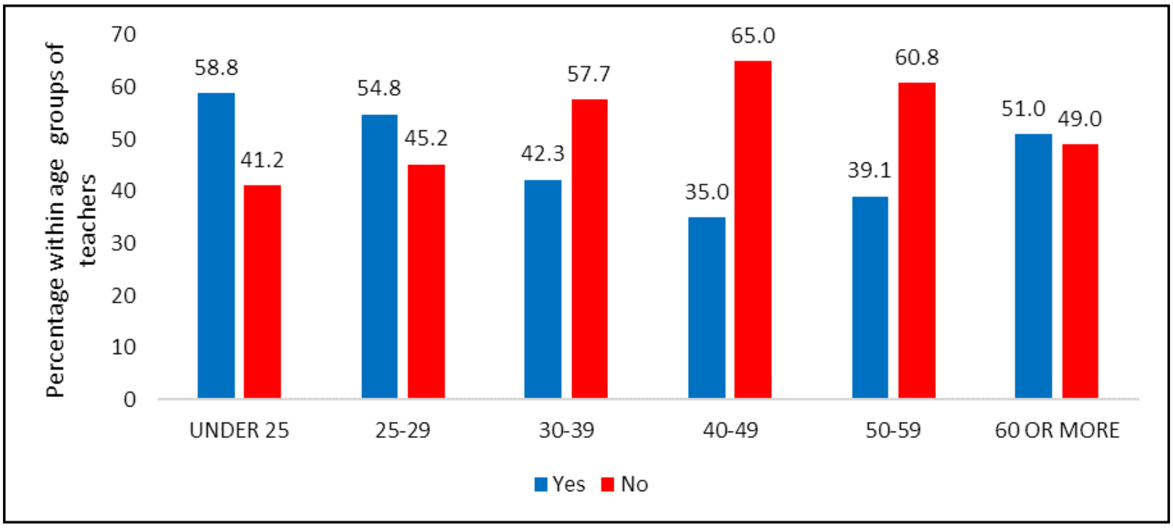

Figure 19: Computer preparation across age groups

Years of teaching experience

From Table 7 it can be seen that there is a clear relationship between the use of computers for preparation and teaching experience, since the Chi-square p-value is less than 0.05. When investigating the cross tabulation between these two factors (see Addendum A22.2 and Figure 20) it seems that less experienced teachers make use of computers for preparation.

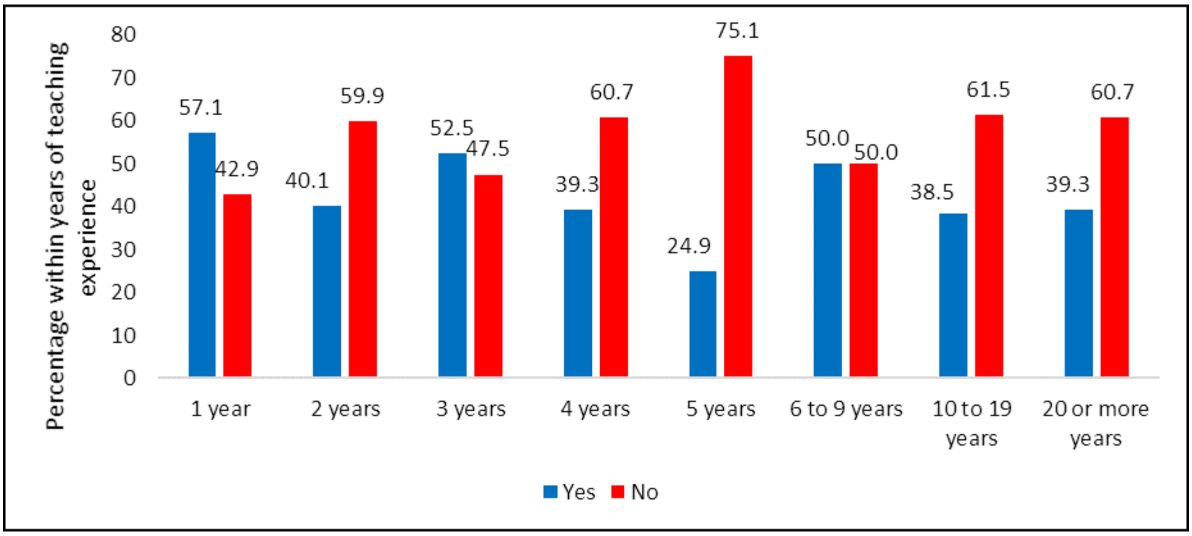

Figure 20: Computer preparation across years of teaching

Province

From Figure 21 it can be seen that the Western Cape is the province where the most respondents answered yes (77.0%) to using a computer for preparation as opposed to Mpumalanga where the least number of respondents answered yes (19.0%) to making use of a computer for preparation. From Table 7 it can be seen that there is a dependency between using computers for preparation and province (p-value <0.001).

Table 7: Chi-square test statistics and p-values for computers for preparation[2]

	Test statistic	df	p-value	Outcome
Computers for preparation and gender	1.570	1	0.210	Independent
Computers for preparation and age	188.584	5	0.000	Dependent
Computers for preparation and years of teaching experience	230.655	7	0.000	Dependent
Computers for preparation and province	993.986	8	0.000	Dependent

The fact that the majority of respondents, who use computers for preparation, are from the Western Cape, can be a result of the Khanya project which has been initiated in 2001, aiming at distributing computers to the most of the schools in that province (Isaacs, 2007). To reiterate, Figure 21 shows that, within Mpumalanga there is the highest percentage of reluctance (81.0%) to using computers for preparation. In a developing country, such as SA, a possible reason why teachers are not using computers for the purpose of preparation, could be that they do not have access to computers at school or at home. However, the reasons why teachers do not use computers for preparation needs further investigation.

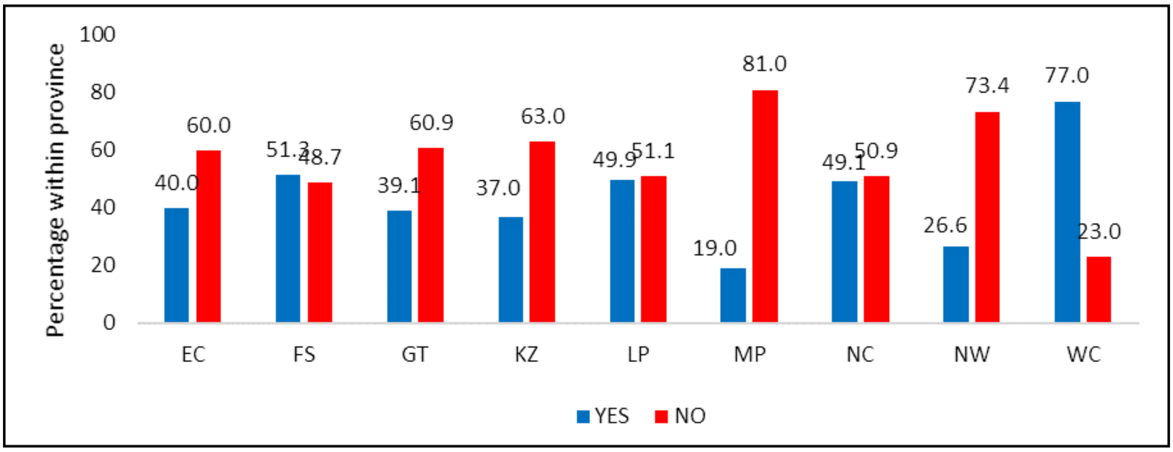

Figure 21: Computers for preparation per province

[2] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

4.3.2 Computers for administration

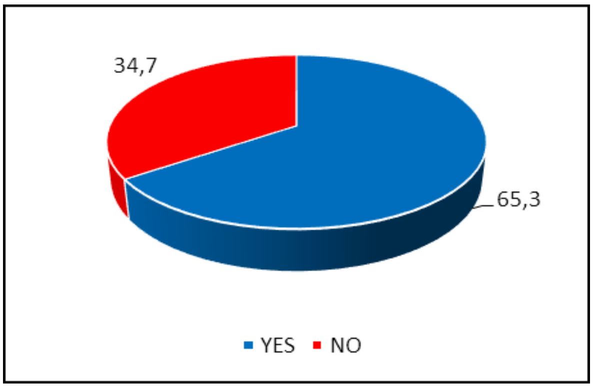

Figure 22: Computers for administration

Figure 22 illustrates the use, or lack thereof, of computers for administration and it can be seen that 65.3%, of the respondents use computers for administration purposes. It emerged that more teachers are using computers for administration (65.3%- Figure 22) than for preparation (35.5% - Figure 17).

Gender

Of the respondents, who indicated that they use computers for administration, 71.5% were female (see Figure 23). Even though more females use computers for administration, results showed that more males (41.6%) than females use computers for preparation as illustrated in Figure 18.

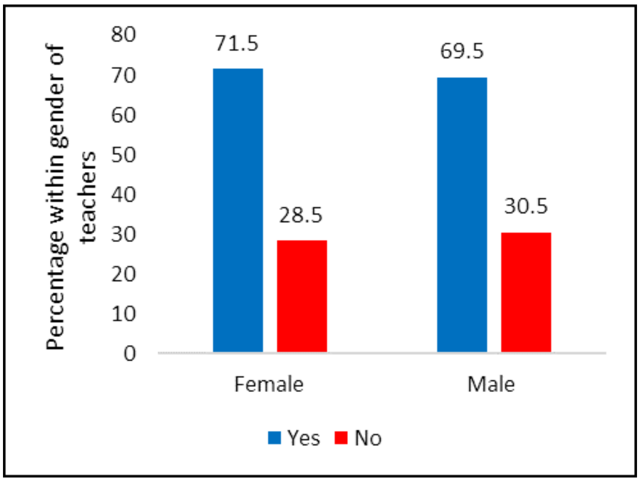

Figure 23: Computers for administration per gender

A relationship is clear between the teachers who use computers for administration and their gender (p-value = 0.021; see Table 8), since it is mostly females who use computers for their administration (see Addendum A25.2).

Table 8: Chi-square test statistics and p-values for computers for administration[3]

	Test statistic	df	p-value	Outcome
Computers for administration and gender	5.329	1	0.021	Dependent
Computers for administration and age	345.726	5	0.000	Dependent
Computers for administration and years of teaching experience	90.455	7	0.000	Dependent
Computers for administration and province	334.020	8	0.000	Dependent

Age

Figure 24 shows that respondents under the age of 25 (88.1%) and between the ages of 25 and 29 years (72.9%) are making use of computers for administration. From Figure 24 it seems that the older age groups are not making use of computers for administration, with respondents answering no 32.2%, 33.6% and 30.8% in the age categories 40 to 49 years of age, 50 to 59 years of age and 60 years or more, respectively. Furthermore, the use of computers for administration and age are also dependent (p-value <0.001; see Table 8) since the majority of the older teachers indicated that they do not make use of computers for administrative purposes (see Addendum A24.2).

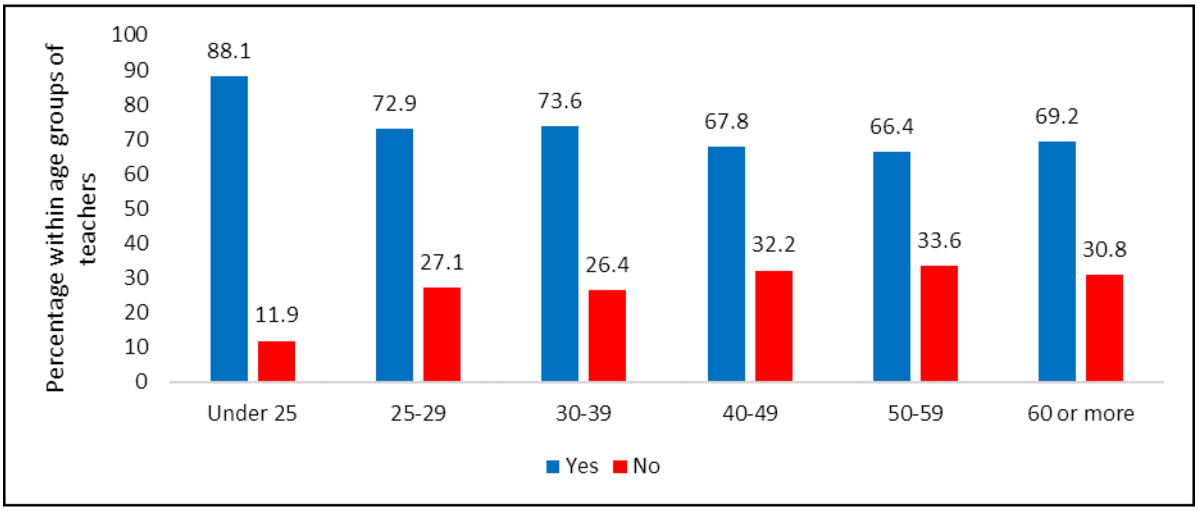

Figure 24: Computers for administration across age groups

[3] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Years of teaching experience

Table 8 shows clear evidence of an association between the teachers who use computers for administration and their years of teaching experience since the p-value is less than 0.05. In other words, it seems that teachers with fewer years teaching experience are more likely to use computers for administrative purposes than their more experienced counterparts (see Addendum A26.2 and Figure 25).

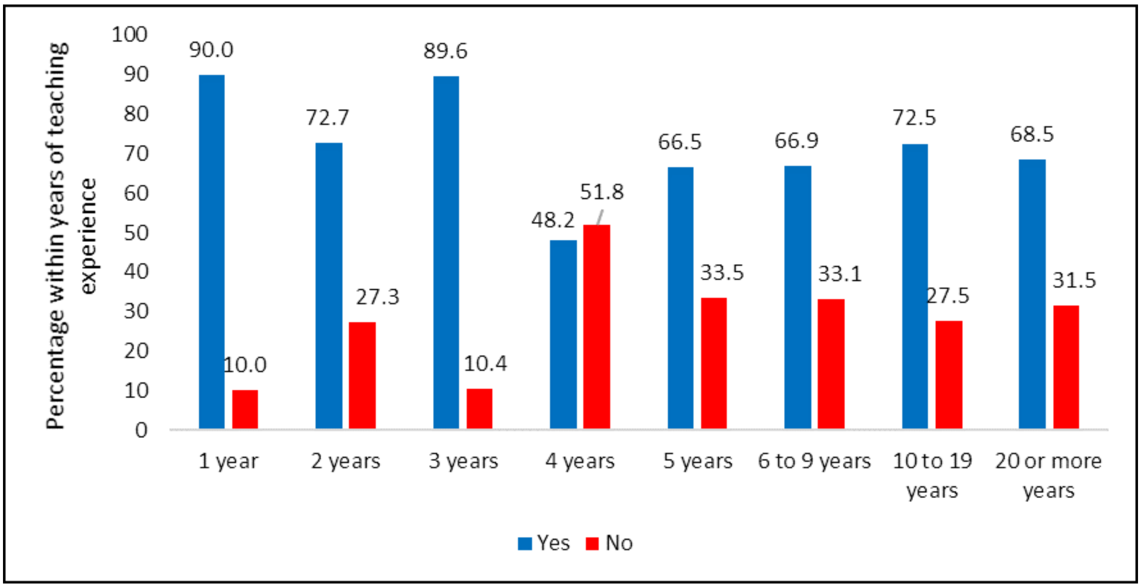

Figure 25: Computers for administration across years teaching

Province

From Figure 26 it can be seen that 91.0% of the respondents from the Western Cape use computers for administration. So far, it looks as if it is mostly teachers under 25, teachers between 25 and 29 of age and teachers from the Western Cape who use computers for preparation and administration. Furthermore, 38.8% of the respondents, who do not use computers for administrative purposes, are from KwaZulu-Natal (see Figure 26). There is a dependency between using computers for administration and province (p-value <0.001); see Table 8.

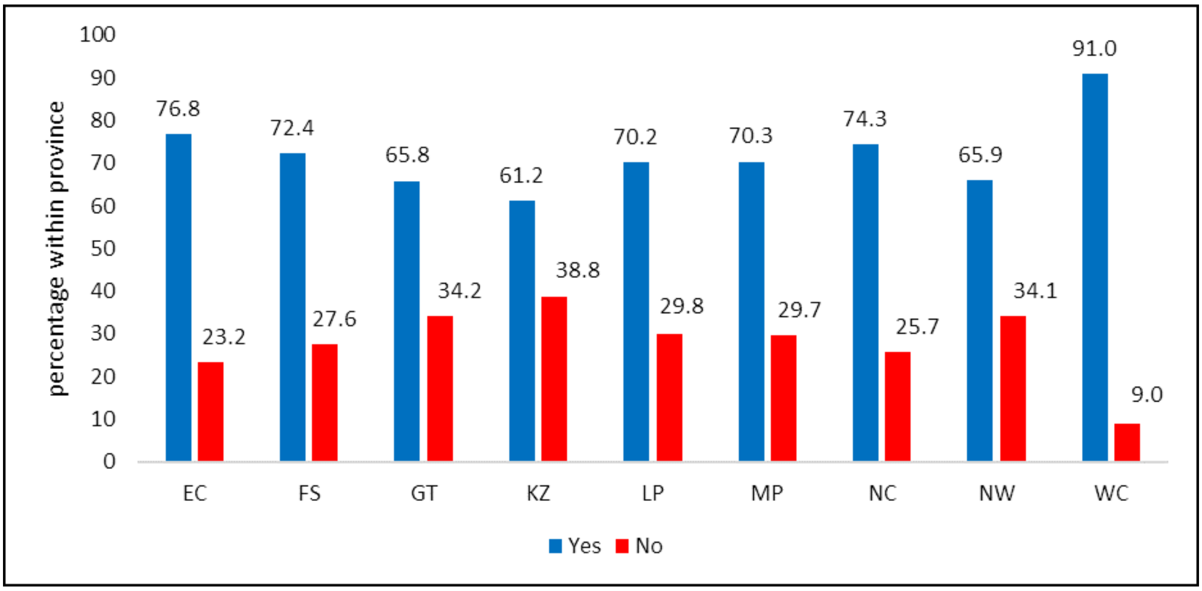

Figure 26: Computers for administration per province

4.3.3 Computers for classroom instruction

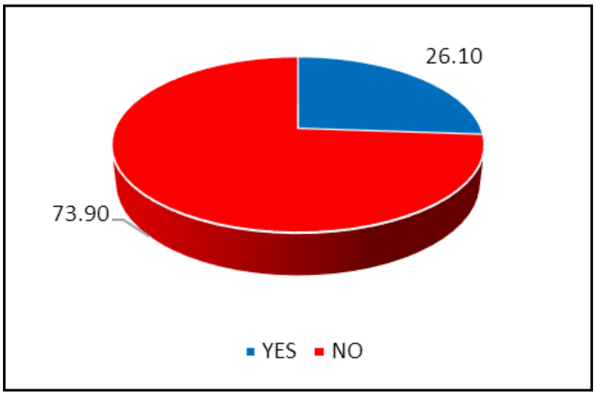

Figure 27: Computers for instruction

Only 26.1% of the respondents use computers in their classroom instruction (see Figure 27). This percentage is low when comparing it to the percentages of teachers that make use of computers for administration (65.3% - Figure 22) and for preparation (35.5% - Figure 17).

Gender

Results show that 36.0% of the respondents were male teachers, who use computers for classroom instruction, see Figure 28. The use of computers for instruction and gender are also dependent with a p-value <0.001 (see Table 9) since it seems that males tend to make use of computers for instruction more than females.

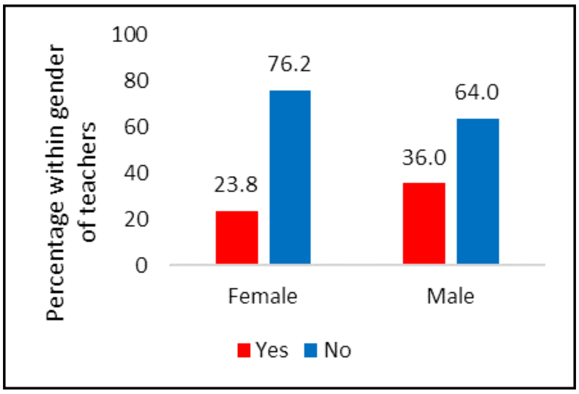

Figure 28: Computers for instruction per gender

Table 9: Chi-square test statistics and p-values for computers for instruction[4]

	Test statistic	df	p-value	Outcome
Computers for instruction and gender	193.089	1	0.000	Dependent
Computers for instruction and age	313.377	5	0.000	Dependent
Computers for instruction and years of teaching experience	42.743	7	0.000	Dependent
Computers for classroom instruction and province	671.992	8	0.000	Dependent

Age

Respondents who are most likely to integrate computers in their classrooms are 60 years and older (37.9%); see Figure 29. Interestingly, the older teachers, who are between 50 and 59 years of age, are still reluctant to adopt computer integration with a low percentage of only 27.7%. Evidently, the use of computers for classroom instruction and age are dependent since the p-value is less than 0.001 (see Table 9).

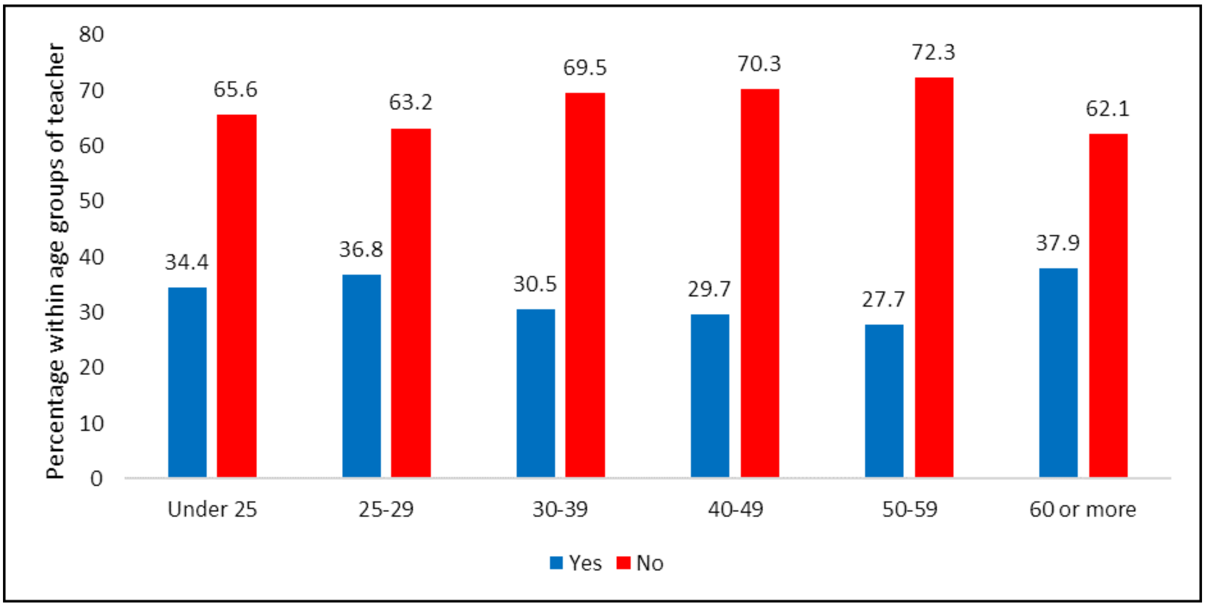

Figure 29: Computers for instruction across age groups

[4] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Years of teaching experience

There is a relationship between the use of computers for instruction and years of teaching experience, since the p-value is less than 0.001 (see Table 9).

The interested reader is referred to Addendum A30.2 where it can be seen that the percentages are not equally distributed in each cell in the cross tabulations between computers for instruction and years of teaching experience, further indicating dependence. Using Addendum A30.2 it is difficult to say whether less or more experienced teachers are making use of computers for instruction, because, we have, for example, 27.0% of respondents with 2 years' experience answering yes compared to 24.9% of respondents with 20 or more years' experience answering yes (See Figure 30). It does happen, sometimes, that a pattern is not clearly discernible in the cross tabulation, however, it comes down to the percentages not being equally distributed across cells that cause the dependence between the two factors.

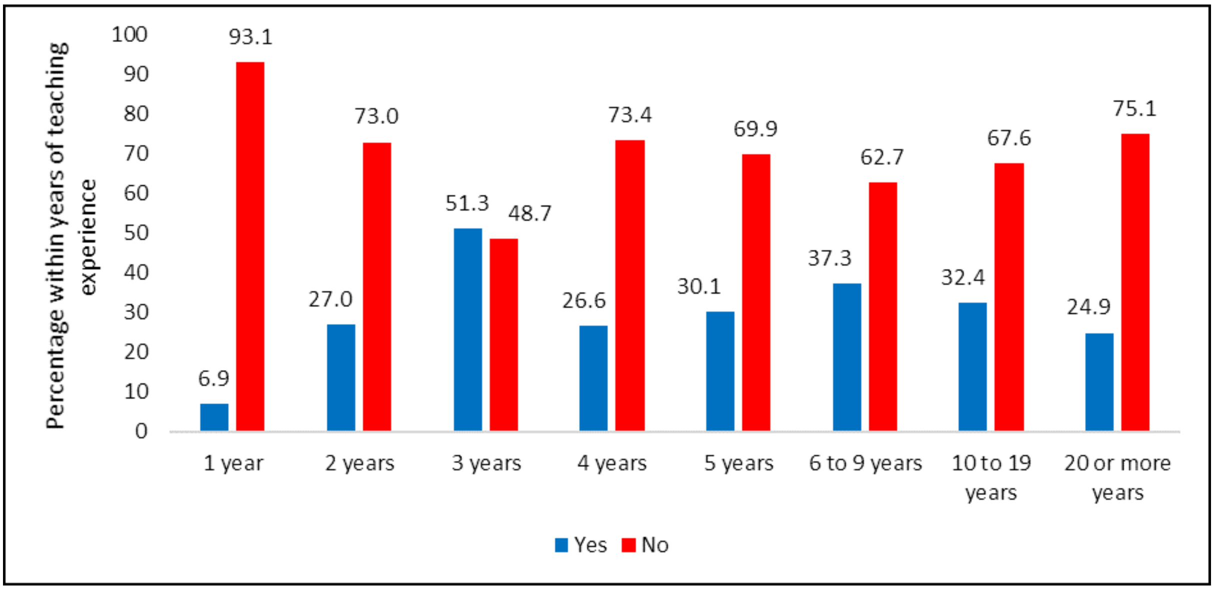

Figure 30: Computers for instruction across years teaching

Province

Within the Western Cape (57.2%) and the Northern Cape (45.2%) the majority of the respondents are using computers in classroom instruction (see Figure 31). There is a dependency between using computers for classroom instruction and province (p-value <0.001); see Table 9. It is no surprise that the Western Cape educators are leading in computer integration in mathematics. As mentioned earlier the Western Cape Education Department (WCED) initiated the Khanya project which aimed at ensuring that most of the schools in the province have been equipped with computers (Isaacs, 2007). That could be one of the reasons why the majority of their teachers are integrating computers. The GDE also initiated Gauteng online in 2001, however educators were of the opinion that Gauteng online was mostly offline (Mukendwa, 2013). Furthermore, results revealed that in the North West (86.8%) followed by the Eastern Cape (81.5%) the majority of the respondents were not making use of computers for classroom instruction (see Figure 31).

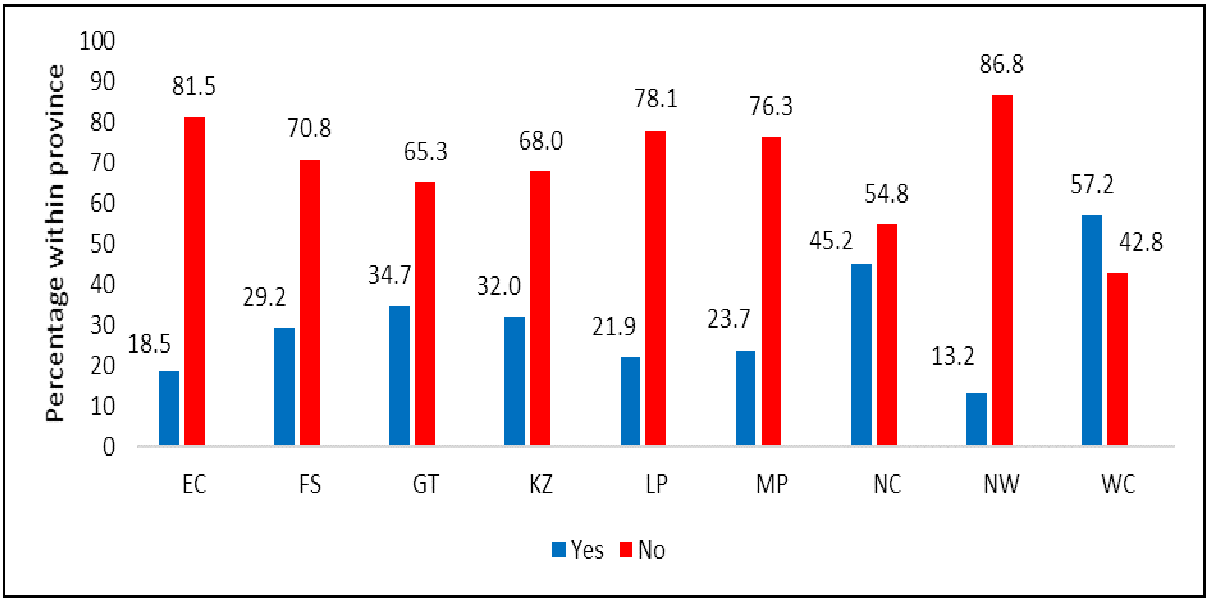

Figure 31: Computers for classroom instruction per province

4.3.4 Reasons for using computer software

Figure 32 is an illustration of the different reasons for using computer software. Results show that the merely 5.1% of the respondents use computer software as basis for instruction. Only a few (18.7%) teachers use computer software to supplement their traditional teaching method. The majority (76.2%) indicated that they do not use computer software at all.

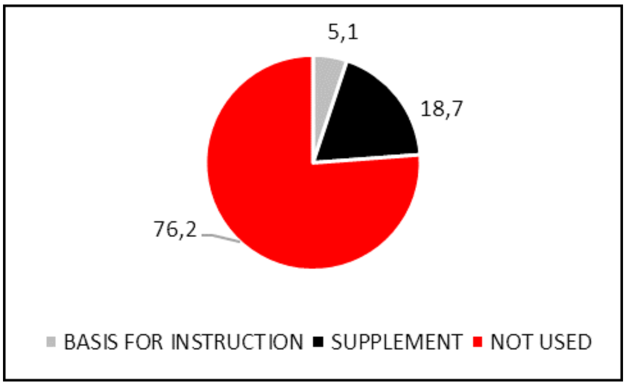

Figure 32: Reasons for using computer software

Gender

From Figure 33 it can be seen that, 6.3% of the respondents were males who use computer software as basis of instruction and as a supplement (23.3%). In total, 80.5% of females reported that they don't make use of computer software. Moreover, an association exists between the gender reasons for using computer software since the p-value is less than 0.001 (see Table 10).

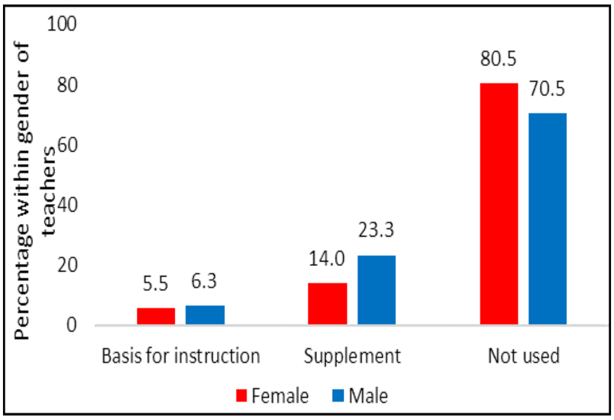

Figure 33: Reasons for using computer software across gender

Table 10: Chi-square test statistics and p-values for reasons for using computer software[5]

	Test statistic	df	p-value	Outcome
Reasons for using computer software and gender	228.966	2	0.000	Dependent
Reasons for using computer software and age	506.397	10	0.000	Dependent
Reasons for using computer software and years of teaching experience	710.6949	14	0.000	Dependent
Reasons for using computer software and province	1686.118	16	0.000	Dependent

Age

Figure 34 shows that it is typically respondents between 25 and 29 years of age (11.3%) who use computer software as a basis for instruction. It is interesting to note the respondents in the age group 60 years and older (36.9%) make use of computer software as a supplement. Furthermore, results indicate that it is mostly the respondents under 25 years of age (87.4%) who don't use computer software at all. It is notable that the younger teachers seem to be more willing to use computers for preparation and administration than the older generation as illustrated in Figure 19

[5] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

and Figure 24, respectively. To use computers for these two reasons typically means that they use computers as cognitive/production tools. Perhaps their age and the times we live in make them more willing to work with computers as tools. On the other hand, in this section it seems as if older teachers make more use of computer software (typically described as e-learning). Computing software typically does the work for you (e.g. you simply put in the CD/run the programme, and the magic happens) meaning that much less computing skills are needed. Furthermore the age of the teachers and these reasons are also dependent since the percentages are spread unevenly in each cell across different categories (see Addendum A45.2) and the p-value is less than 0.05 (see Table 10).

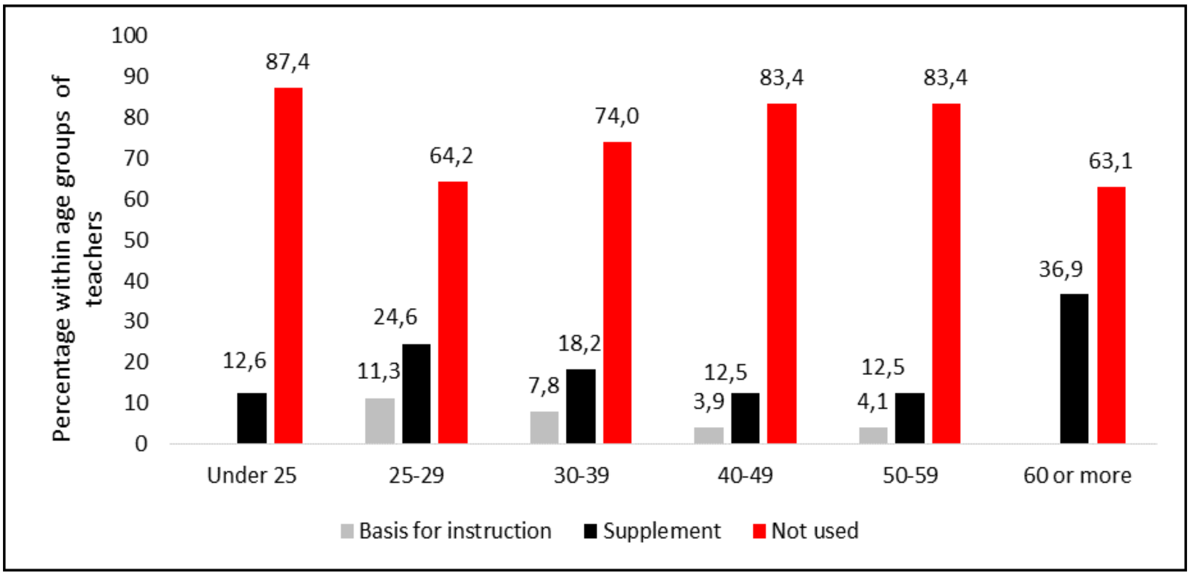

Figure 34: Reasons for using computer software across age groups

Years of teaching experience

There is also a relationship between the different reasons teachers use computer software for and their years of teaching experience since the p-value is less than 0.05, which indicates dependence (see Table 10). From Addendum A47.2 and Figure 35 it can be seen that the percentages are not equally distributed across cells which reiterates the dependence between the two factors.

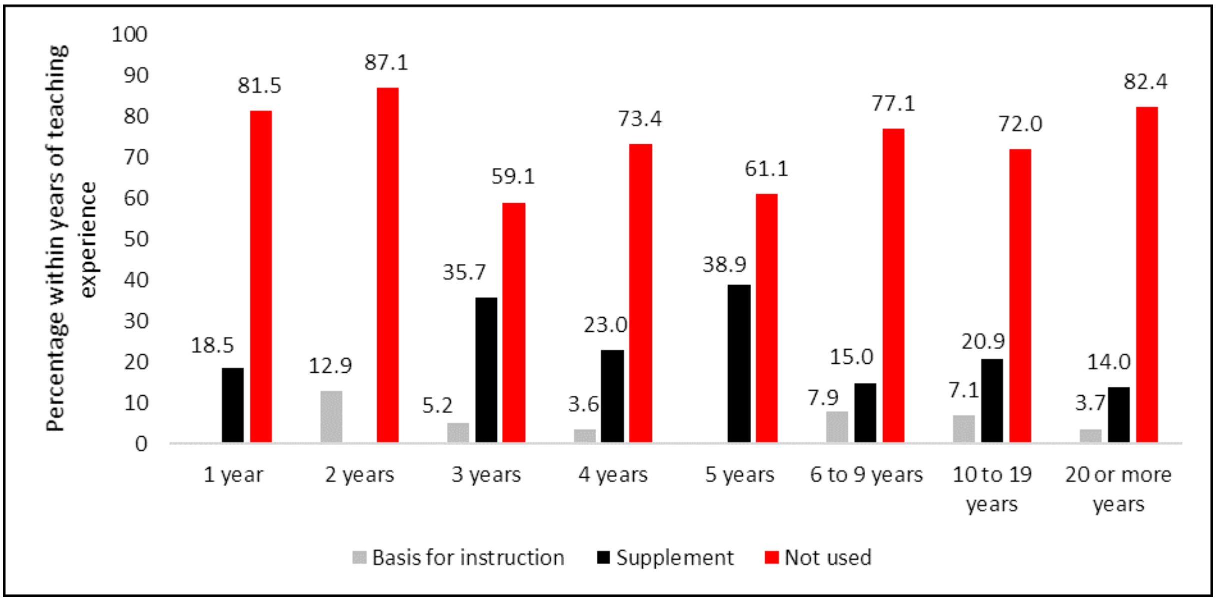

Figure 35: Reasons for using computer software across years teaching

Province

From Figure 36 it can be seen that the majority of respondents, who use computers as basis for instruction, are from KwaZulu-Natal (12.5%). When considering the Western Cape, it is the only province with the majority of the respondents making use of computers as a supplement (57.7%). When considering Mpumalanga province, it can be seen that this province has the most teachers (93.4%) who do not use computer software at all. There is a dependency between using computers for classroom instruction and province (p-value <0.001); see Table 10.

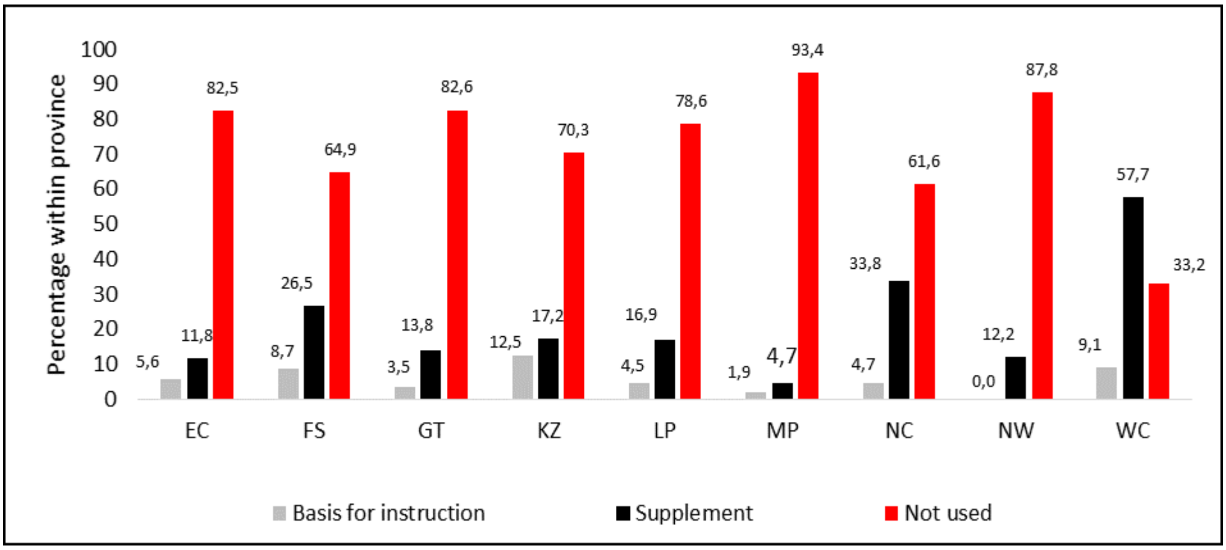

Figure 36: Reasons for using computer software across provinces

4.3.5 Computers to explore concepts in mathematics

From Figure 37 it can be seen that only a few (11.2%) respondents indicated that they use computers "every or almost every day". A total of 64.0% of respondents reported that they never or almost never use computers to explore concepts in mathematics.

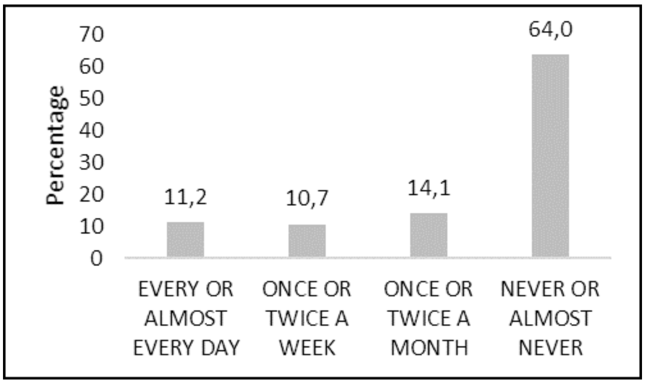

Figure 37: Computers to explore concepts

Gender

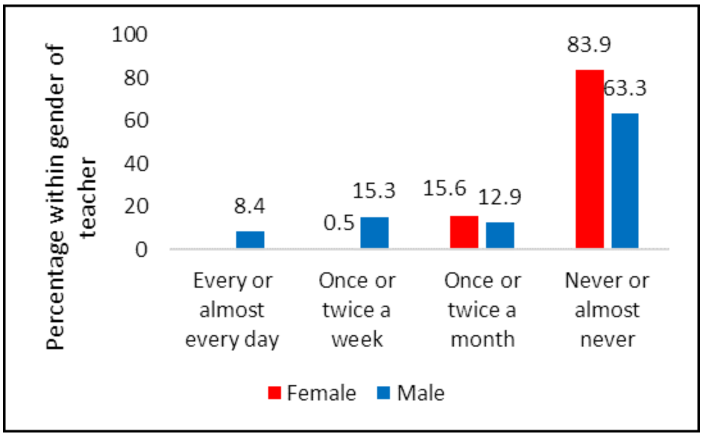

Figure 38: Computers to explore concepts across gender

Results indicate that 8.4% of the respondents were males who explore concepts using computers "every or almost every day" (see Figure 38). Moreover, there is a clear relationship between gender and the use of computers to explore concepts because more than 80% of the females report that they don't make use of computers for this purpose. From Table 11 it can be seen that gender and the use of computers to explore concepts are dependent, since the p-value <0.001.

Table 11: Chi-square test statistics and p-values for computers to explore concepts[6]

	Test statistic	df	p-value	Outcome
Computers to explore concepts and gender	167.164	3	0.000	Dependent
Computers to explore concepts and age	261.024	15	0.000	Dependent
Computers to explore concepts and years of teaching experience	634.714	21	0.000	Dependent
Computers to explore concepts and province	1228.359	24	0.000	Dependent

Age

Overall, 9.5% of the respondents were between 25 and 29 years of age who uses computers to explore concepts "every or almost every day" (see Figure 39). All the respondents 60 years and older reported that they did not make use of computers to explore concepts in their classrooms (see Addendum A49.2). The p-value is less than 0.001 (see Table 11) indicating that age and the use of computers to explore concepts are dependent.

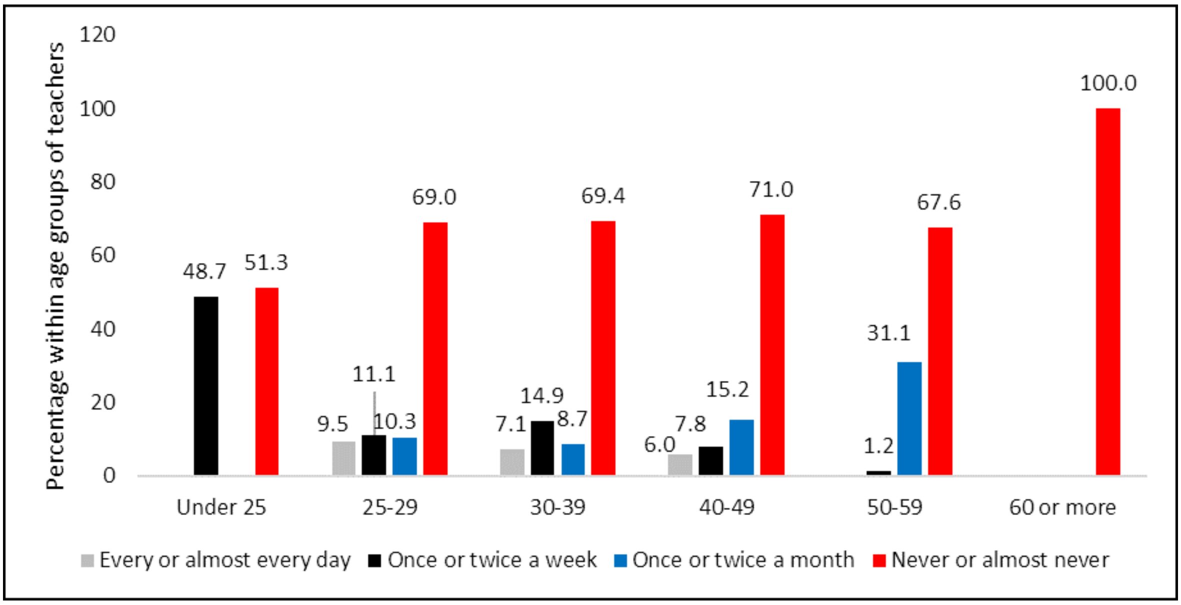

Figure 39: Computers to explore concepts across age

[6] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Years of teaching experience

The Chi-square test revealed that the use of computers for concepts and the years of teaching experience are related since the p-value is less than 0.001 (see Table 11). Using Addendum A51.2 it is difficult to say whether less or more experienced teachers are making use of computers to explore concepts, because, we have, for example, 18.4% of respondents with 3 years' experience answering yes compared to 19.9% of respondents with between 10 and 19 years' experience answering that they make use of it every or almost every day (see Figure 40). It does happen, sometimes, that a pattern is not clearly discernable in the cross tabulation, however, it comes down to the percentages not being equally distributed across cells that cause the dependence between the two factors.

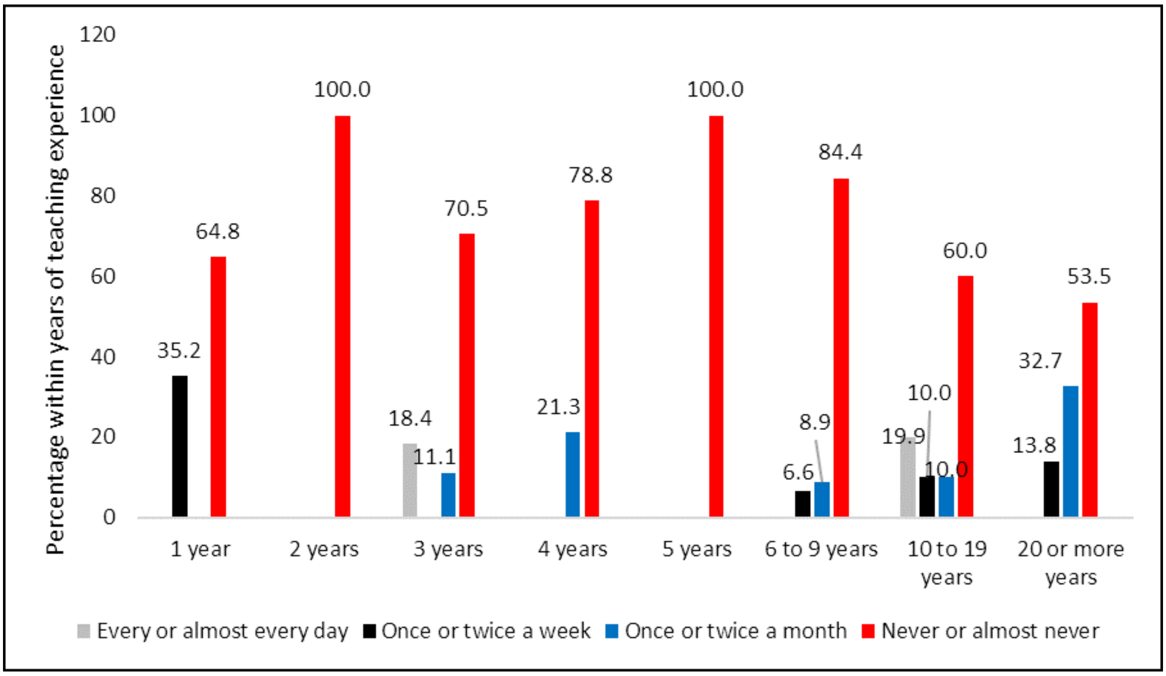

Figure 40: Computers to explore concepts across years teaching

Province

It was detected that all (100%) of the respondents from Mpumalanga and the Northern Cape never or almost never used computers to explore concepts (see Figure 41) which is concerning.

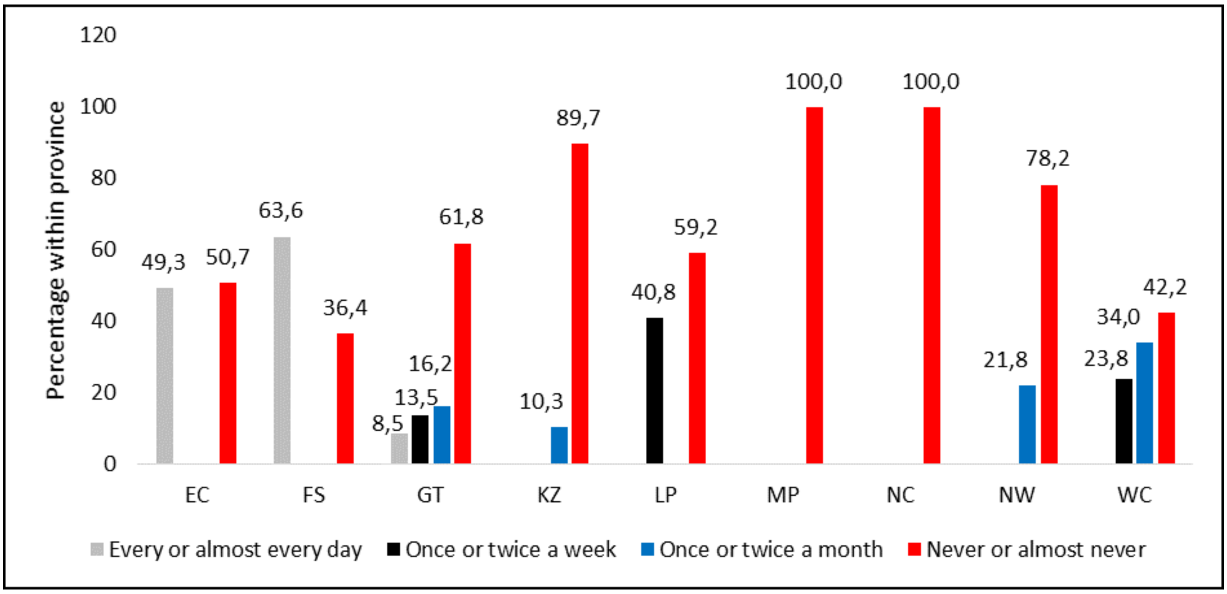

Figure 41: Computers to explore concepts per province

4.3.6 Computers to do procedures in mathematics

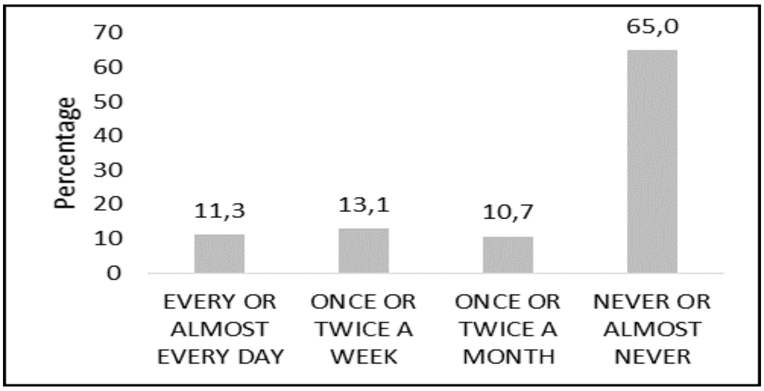

Figure 42: Computers to do procedures

Figure 42 shows that only 11.3% of the respondents use computers for procedures “every or almost every day”. Teachers indicated that they never or almost never (65.0%) use computers for procedures in mathematics.

Gender

From Figure 43 it can be seen that 8.4% of the respondents use computers to do procedures. On the other hand, a total of 85.5% of the respondents were females who don’t use computers for procedures. In addition, an association exists between gender and using computers to do procedures since the p-value is less than 0.001 (see Table 12).

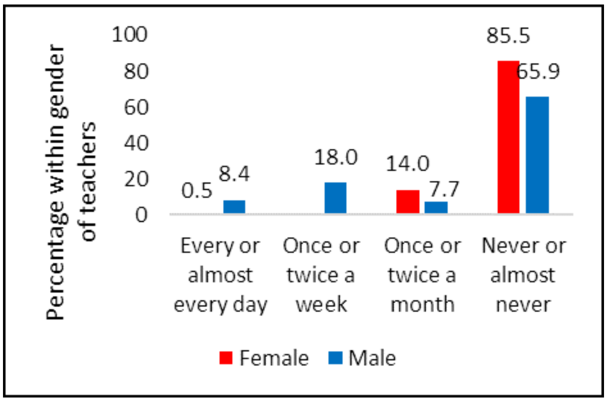

Figure 43: Computers to do procedures across gender

Table 12: Chi-square test statistics and p-values for computers to do procedures[7]

	Test statistic	df	p-value	Outcome
Computers to do procedures and gender	196.588	3	0.000	Dependent
Computers to do procedures and age	159.541	15	0.000	Dependent
Computers to do procedures and years of teaching experience	521.962	21	0.000	Dependent
Computers to do procedures and province	1295.965	24	0.000	Dependent

Age

Respondents between the ages of 25 and 29 is the age category that is using computers, the most to do procedures every day or almost every day (see Figure 44). Evidently, the use of computers to do procedures and age are dependent since the p-value is less than 0.001 (see Table 12). Furthermore, 100% of the teachers who are 60 years and older reported that they don't use computers for this purpose (see Figure 44).

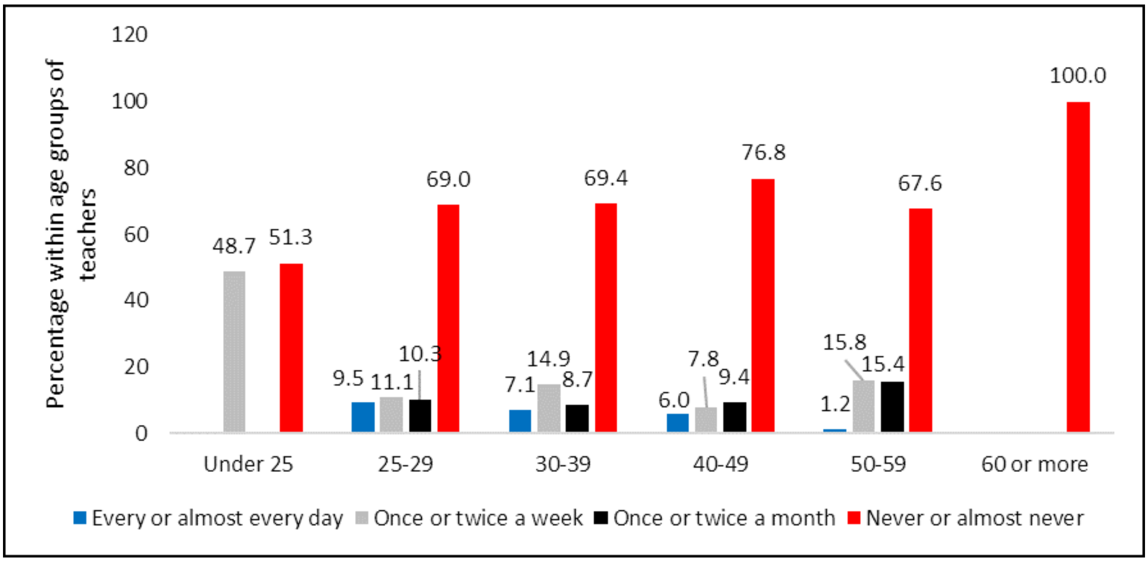

Figure 44: Computers to do procedures across age groups

[7] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, repor ted as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Years of teaching experience

Table 12 shows dependence between the use of computers to do procedures and years of teaching experience, since the p-value is less than 0.05. Using Addendum A55.2 it is difficult to say whether less or more experienced teachers are making use of computers for instruction, because, we have, for example, 18.4% of respondents with 3 years' experience responding that they use it daily compared to 19.9% of respondents with 10 to 19 years' experience who state they use it daily (see Figure 45). It does happen, sometimes, that a pattern is not clearly discernable in the cross tabulation, however, it comes down to the percentages not being equally distributed across cells that cause the dependence between the two factors.

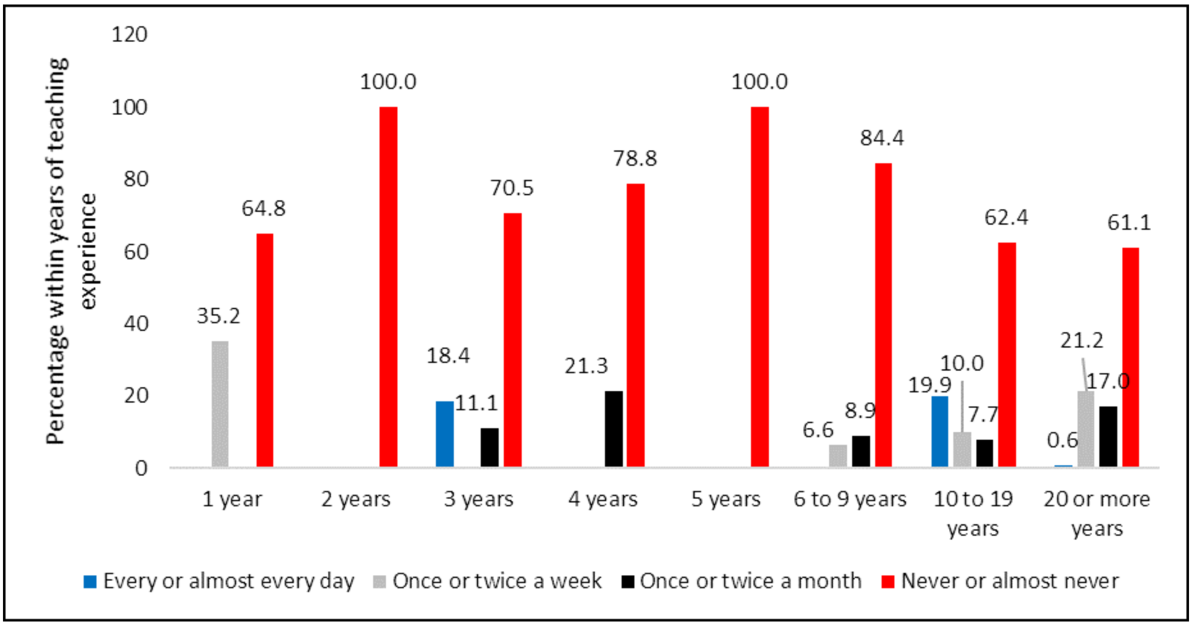

Figure 45: Computers to do procedures across years teaching

Province

From Figure 46 it can be seen that the majority (63.6%) of the respondents that use computers for procedures are from the Free State. All of the respondents from KwaZulu-Natal, Mpumalanga, as well as the Northern Cape, indicate that they do not use computers for procedures in mathematics. There is clearly a dependency between the use of computers to do procedures and province (p-value <0.001); see Table 12.

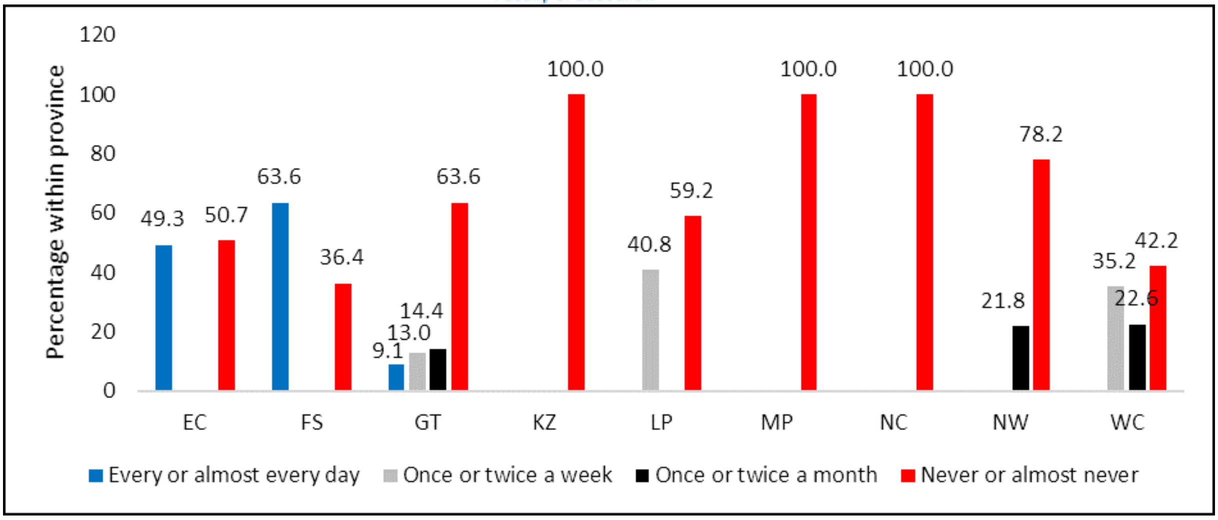

Figure 46: Computers to do procedures per province

4.3.7 Computers to look up ideas in mathematics

Figure 47 is an illustration of the teachers, who responded to the question regarding the use of computers to look up ideas in mathematics. Overall, 11.7% of the respondents use computers to look up ideas every day or almost every day. Many of the teachers indicate that they never, or almost never (57.8%) use computers to look up ideas.

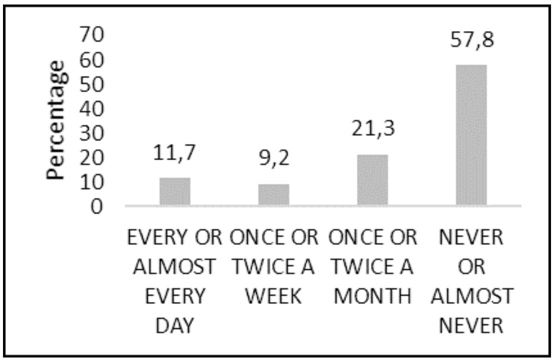

Figure 47: Computers to look up ideas

Gender

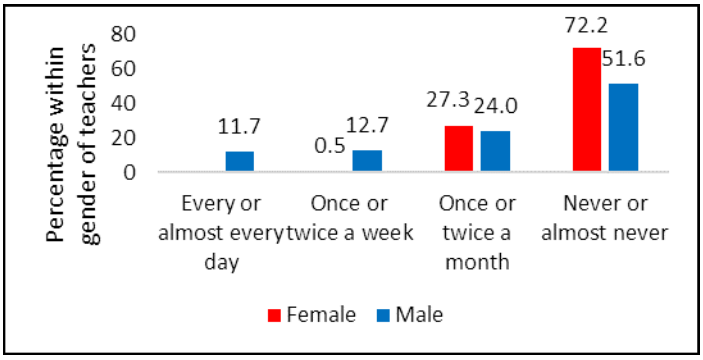

Figure 48: Computers to look up ideas across gender

From Figure 48 it can be seen that 11.7% of the respondents were males who use computers “every or almost every day” to look up ideas compared to only 0% of females using it daily for this reason. There is an association between the use of computers to look up ideas sincethe p-value is less than 0.001 (see Table 13).

Table 13: Chi-square test statistics and p-values for computers to look up ideas[8]

	Test statistic	df	p-value	Outcome
Computers to look up ideas and gender	10006.877	24	0.000	Dependent
Computers to look up ideas and age	333.657	15	0.000	Dependent
Computers to look up ideas and years of teaching experience	954.656	21	0.000	Dependent
Computers to look up ideas and province	1006.877	24	0.000	Dependent

Age

From Figure 49 it can be seen that 16.1% of the respondents were between 30 and 39 years of age use computers "every or almost every day" to look up ideas compared to the other age groups who all have lower percentages. All the respondents 60 years and older indicate that they don't use computers for this purpose. There is dependence between the use of computers to look up ideas and the age since the p-value is less than 0.000 (see Table 13).

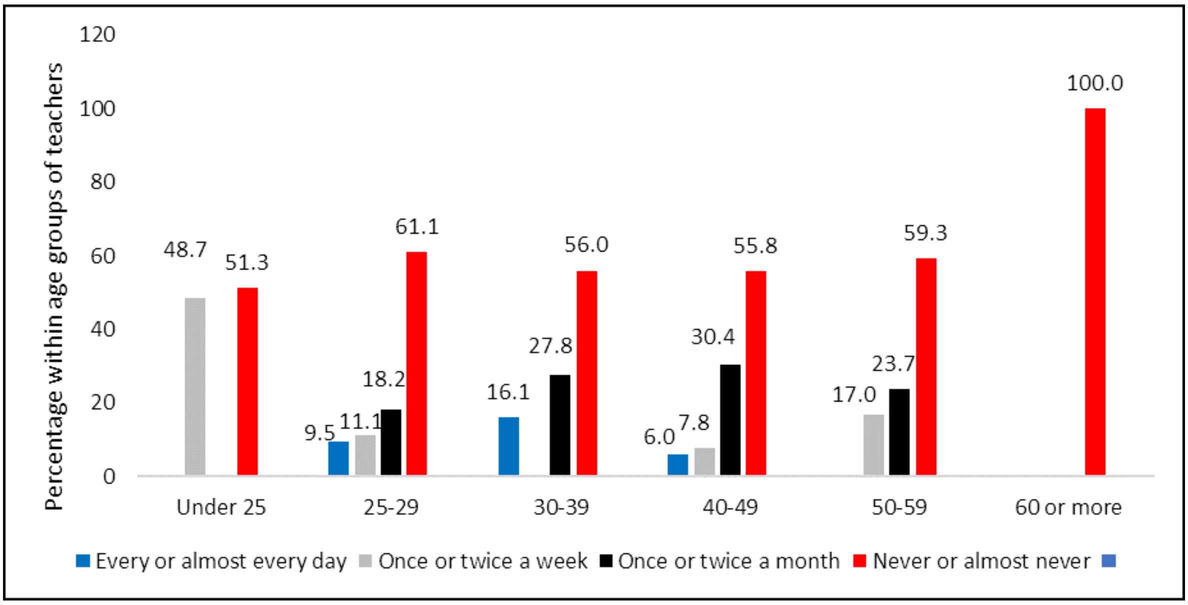

Figure 49: Computers to look up ideas across age groups

[8] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Years of teaching experience

The respondents who use computers to look up ideas and their years of teaching experience are also dependent because cross tabulations shows that more experienced teachers use computers to look up ideas (see Figure 50). The dependence is reiterated by the p-value of 0.000 (see Table 13).

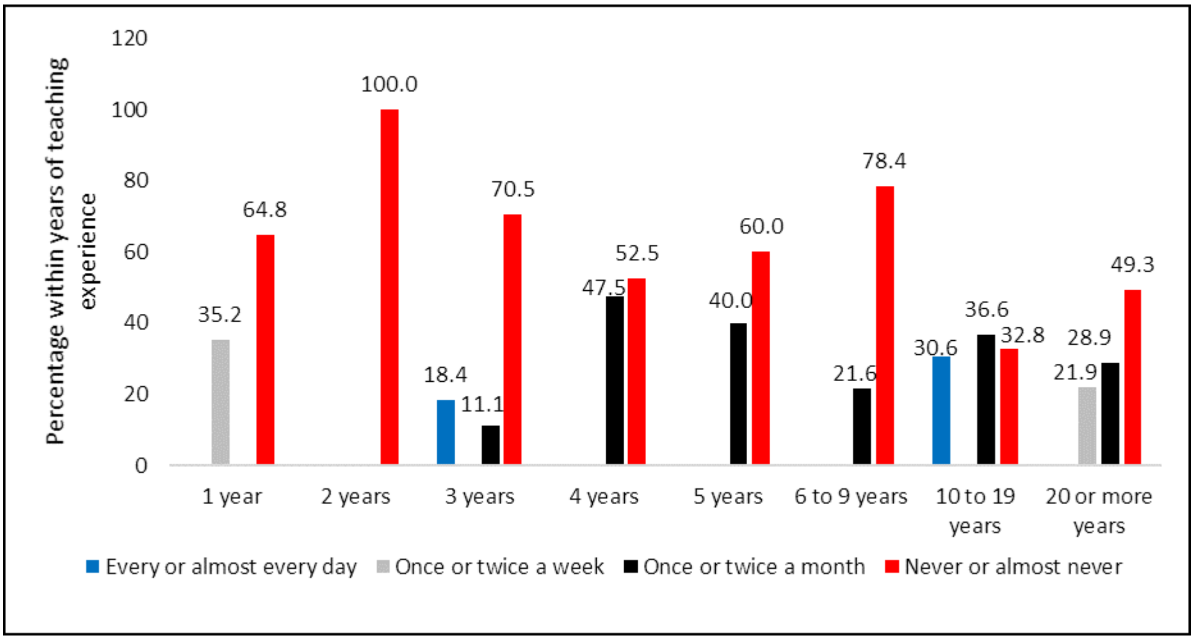

Figure 50: Computers to look up ideas across teaching years

Province

Most respondents from the Free State (63.6%) use computers to look up ideas as illustrated in Figure 51. There is clearly a dependency between the use of computers to look up ideas and province (p-value <0.001); see Table 13. Figure 38 shows that 78.2% of the respondents from the North West never or almost never use computers to look up ideas.

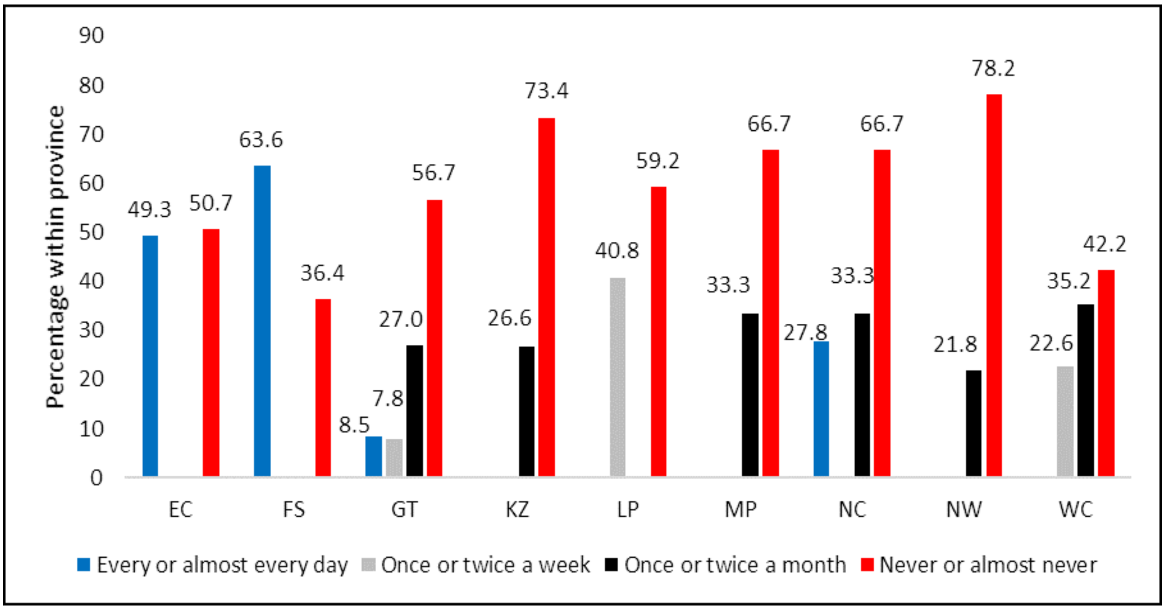

Figure 51: Computers to look up ideas per province

4.3.8 Computers for data processing in mathematics

Figure 52 shows that 62.8% of the respondents never or almost never use computers to process data. Only 11.7% of the respondents are making use of computers to process data in mathematics "every or almost every day".

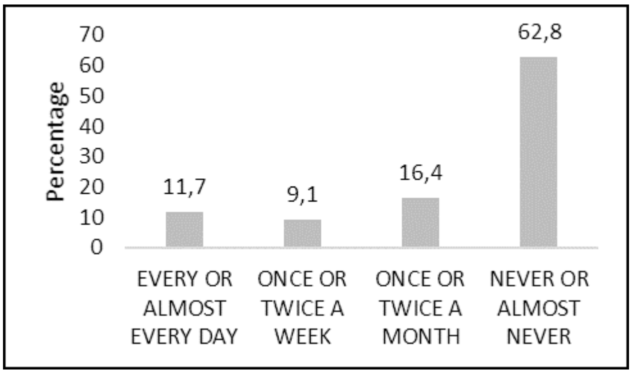

Figure 52: Computers to process data

Gender

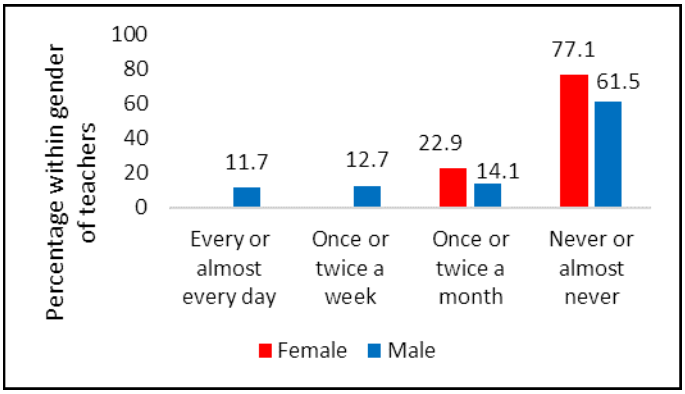

Figure 53: Computers to process data across gender

From Figure 53 it can be seen that it is mostly females (72.2%) who never or almost never use computers to process data. What is alarming is that 61.5% of males also never or almost never use computers to process data. These percentages of 77.1% for females and 61.5% for males are alarming.

There is dependency between the teachers who use computers for data processing and their gender since the p-value less than 0.05 (see Table 14).

Table 14: Chi-square test statistics and p-values for computers to process data[9]

	Test statistic	df	p-value	Outcome
Computers to process data and years of teaching experience	868.397	21	0.000	Dependent
Computers to process data and gender	185.465	3	0.000	Dependent
Computers to process data and age	327.595	15	0.000	Dependent
Computers to process data and province	1198.350	24	0.000	Dependent

Age

It is respondents 60 years and older (100% of them) who never or almost never use computers to process data (see Figure 54). The majority of the respondents who use computers to process data are between 30 and 39 years of age. There is a relationship between age and making use of computers to process data in mathematics. This is evident from Table 14 where the p-value <0.001 (< 0.05).

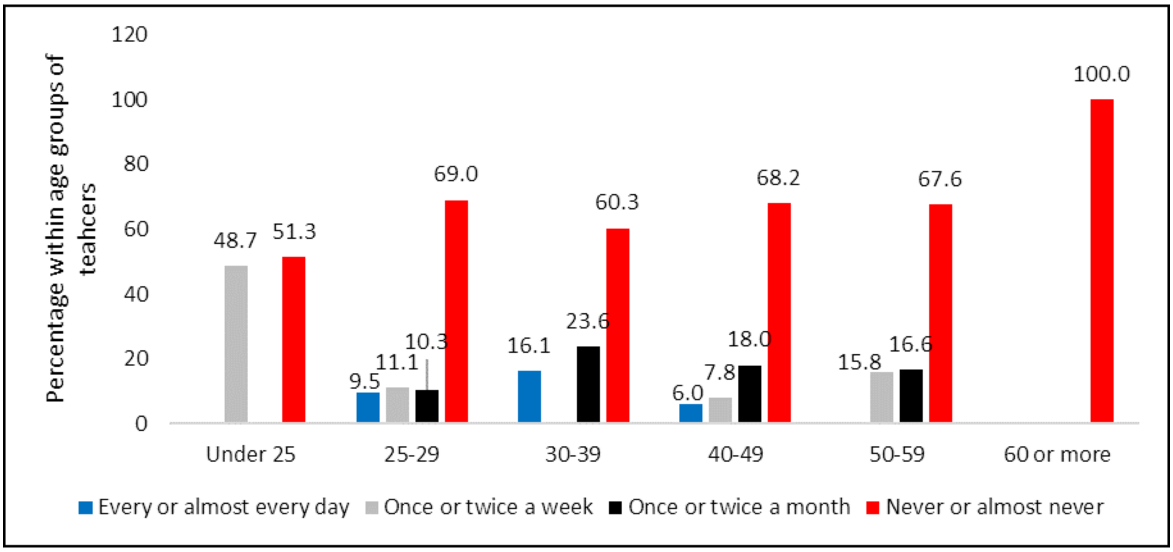

Figure 54: Computers to process data across age groups

9 Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Years of teaching experience

Table 14 shows that the respondents who use computers to process data and their years of teaching experience are dependent because the p-value is less than 0.001. Using Addendum A61.2 it is difficult to say whether less or more experienced teachers are making use of computers for data processing, because we have, for example, 0% of respondents with 1 years' experience saying they use it daily compared to 0% of respondents with 20 or more years' experience saying that they use it daily (see Figure 55). It does happen, sometimes, that a pattern is not clearly discernable in the cross tabulation, however, it comes down to the percentages not being equally distributed across cells that cause the dependence between the two factors.

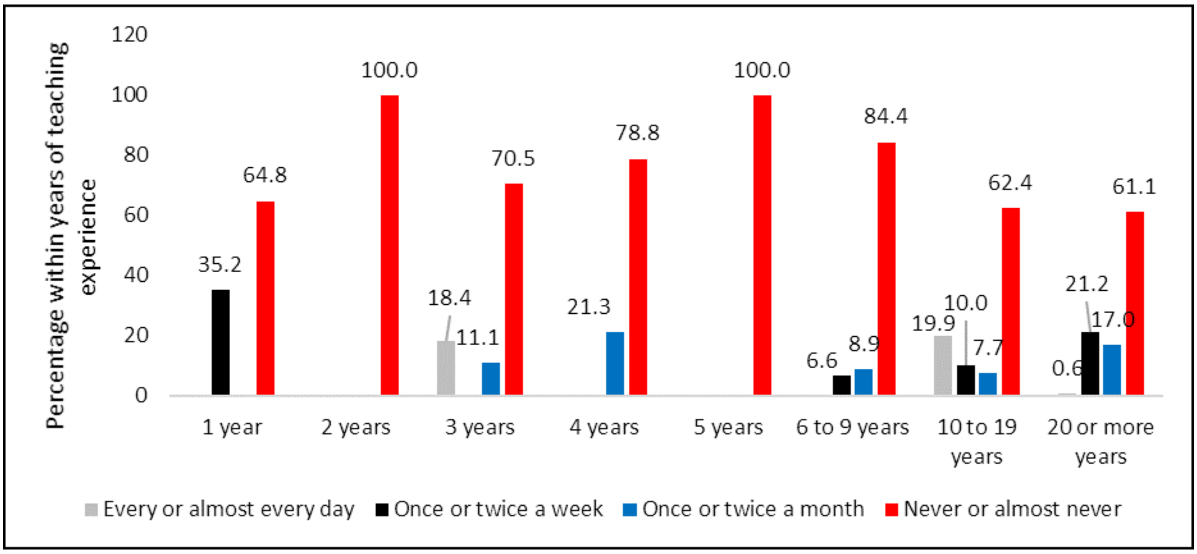

Figure 55: Computers to process data across years teaching

Province

It was found that many of the respondents who indicate that they never or almost never use computers are from Mpumalanga (100%) and KwaZulu-Natal (95.4%); see Figure 56. It emerged that it is the majority of respondents from the Free State (63.3%) who use computers for data processing "every or almost every day". There is clearly a dependency between the use of computers for data processing and province (p-value = 0.000); see Table 14.

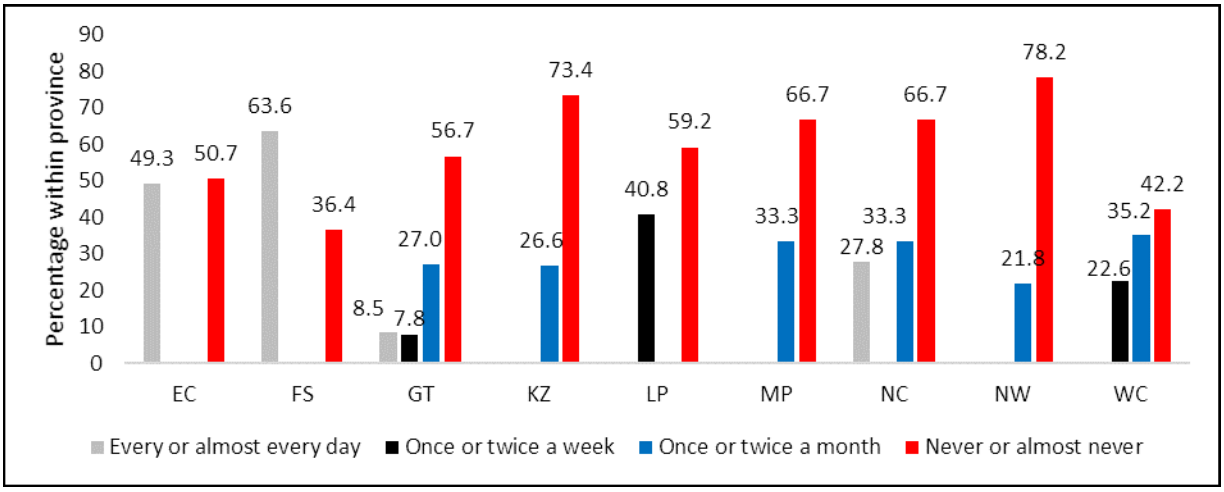

Figure 56: Computers to process data per province

4.4 PERCEPTIONS OF MATHEMATICS TEACHERS REGARDING SUPPORT

4.4.1 Teachers who feel comfortable using computers

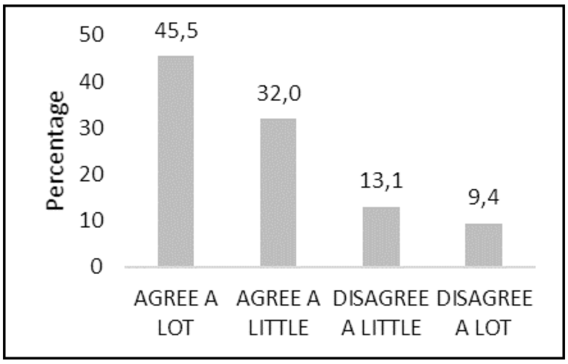

Figure 57: Comfortable using computers

Many respondents (45.5%) "agree a lot" that they are comfortable using computers in their classrooms as illustrated in Figure 57. Only a few of the respondents (9.4%) "disagree a lot" that they are comfortable using computers.

Gender

The majority of females (45.3%) feel comfortable using computers (see Figure 58). On the other hand, it is mostly males (14.5%) who are not comfortable using computers (see Addendum A33.2). There is a relationship between gender and teachers who feel comfortable using computers for it is mostly females who respond that they feel comfortable using computers (see Table 15 where the p-value < 0.05).

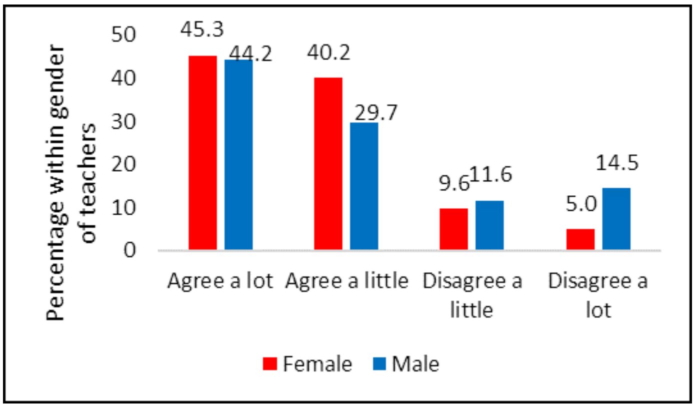

Figure 58: Comfortable using computers across gender

Table 15: Chi-square test statistics and p-values for comfortable using computers [10]

	Test statistic	df	p-value	Outcome
Comfortable using computers and gender	89.832	3	0.000	Dependent
Comfortable using computers and age	373.614	15	0.000	Dependent
Comfortable using computers and years of teaching experience	562.289	21	0.000	Dependent
Comfortable using computers and province	2056.531	24	0.000	Dependent

Age

From Addendum 32.2 it can be seen that 52.3% of the respondents between 25 and 29 years of age feel comfortable using computers. On the other hand, 48.0% of the older (60 years and more) respondents are not comfortable using computers (see Figure 59). The dependency between age and feeling comfortable with using computers is evident from Table 15 where the p-value < 0.05.

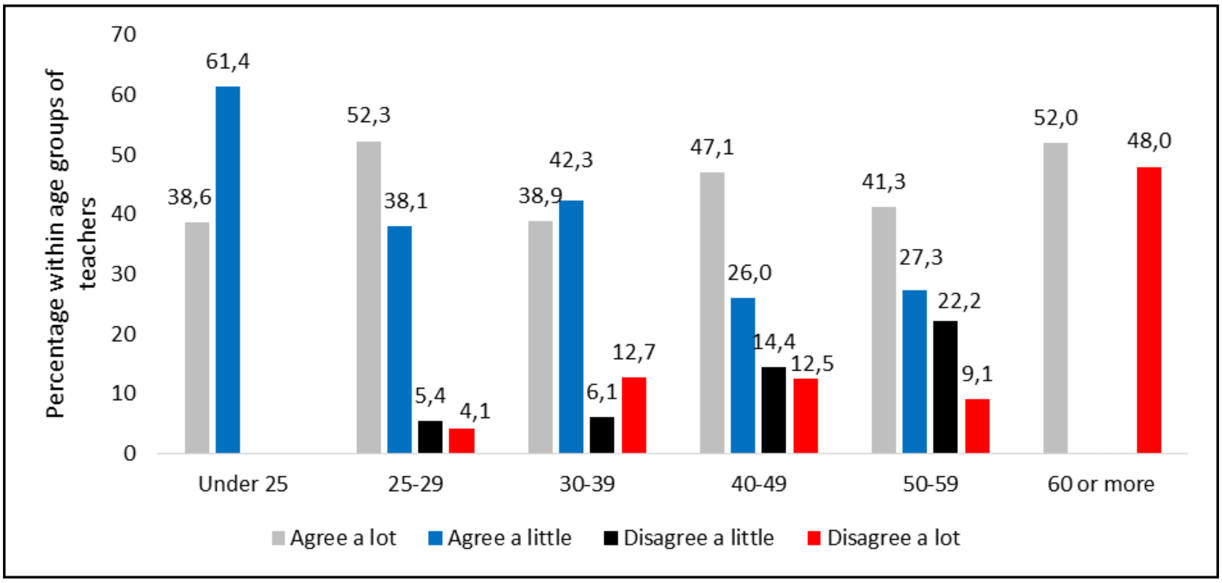

Figure 59: Comfortable using computers across age groups

[10] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Years of teaching experience

From Figure 60 it can be seen that it is the more experienced teachers who don't feel comfortable using computers. Table 15 shows that teachers who feel comfortable using computers and years of teaching experience are dependent, since the p-value is less than 0.05.

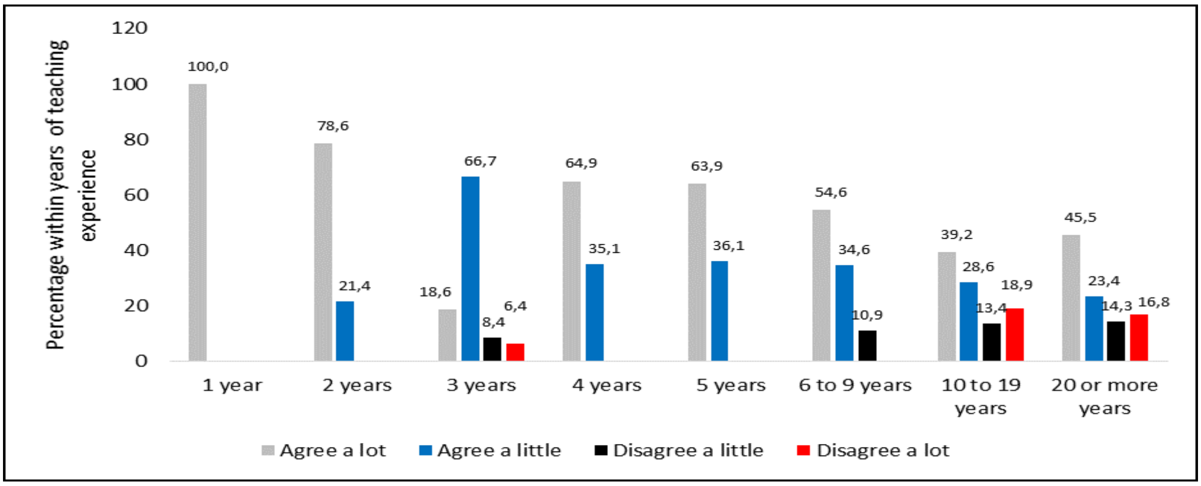

Figure 60: Comfortable using computers across years teaching

Province

From Figure 61 it can be seen that many respondents from KwaZulu-Natal (67.6%) feel comfortable using computers in their classroom. Evidently, 81.3% of the respondents from Mpumalanga "disagree a lot" that they are comfortable using computers. There is a dependency between the teachers who feel comfortable using computers for data processing and province (p-value <0.001); see Table 15.

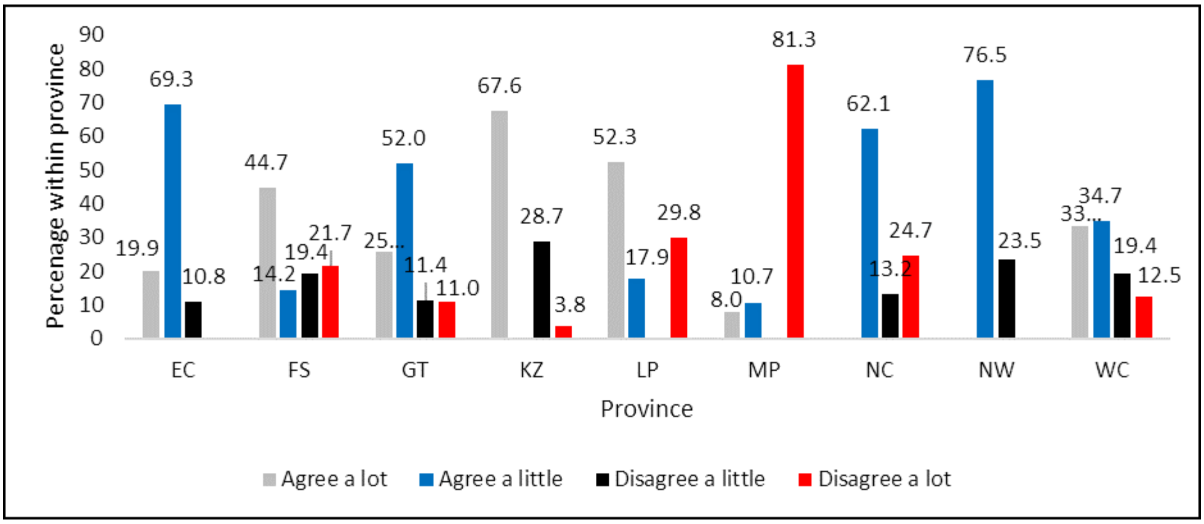

Figure 61: Comfortable using computers per province

4.4.2 Support for technical problems

TIMSS 2011 did not define adequate support as well as technical support which could have confused teachers. Therefore, the data may not be completely reliable. As mentioned in Section 4.2.4, future TIMSS studies should consider attaching a list of definitions to the questionnaires to avoid misinterpretation. However researchers such as Setyaningrum (2016) and Amuko et al., (2015). However, in general, adequate support includes for instance, pedagogical support, support from their principals and school administration, and “capacity building support” (Amuko et al., 2015, p. 1; Setyaningrum, 2016). On the other hand technical support refers to the need of technical staff to maintain hardware and software (Dotong et al., 2016).

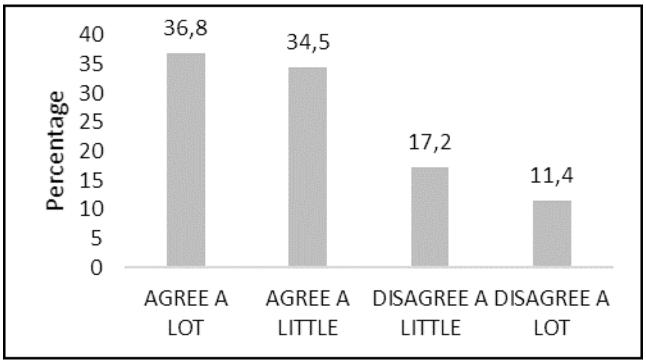

Figure 62: Support for technical problems

The teachers were asked to indicate their opinions regarding support for technical problems while integrating computers. Figure 62 shows that the majority (36.8%) of the respondents “agree a lot” that they receive technical support when using computers. The minority (11.4%) of the respondents feel that they do not receive technical support.

Gender

Overall, 52.4% of the females are of the opinion that they receive technical support while using computers (see Figure 63). It is mostly males (17.6%) as illustrated in Figure 63, who “disagree a lot” that they receive adequate technical support. There is a relationship between the gender and support for technical problems, for mostly females receive technical support (see Table 16 where the p-value is less than 0.05).

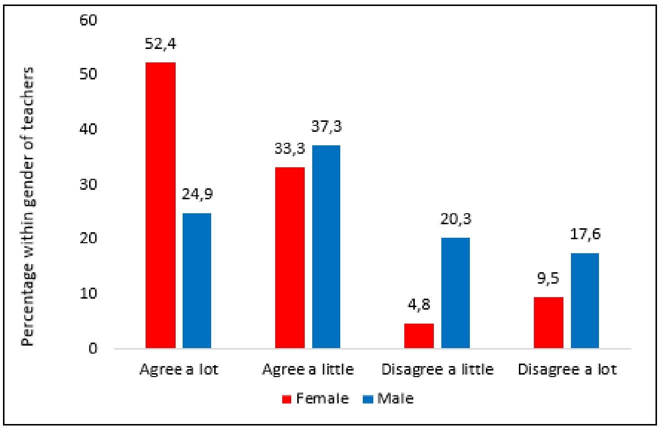

Figure 63: Support for technical problems across gender

Table 16: Chi-square test statistics and p-values support for technical problems[11]

	Test statistic	df	p-value	Outcome
Support for technical problems and gender	315.690	3	0.000	Dependent
Support for technical problems and age	362.185	15	0.000	Dependent
Support for technical problems and years of teaching experience	928.168	21	0.000	Dependent
Support for technical problems and province	1359.739	24	0.000	Dependent

Age

From Figure 64 it can be seen that many respondents 60 years and older (52.0%) are of the view that they receive technical support. Furthermore, it is interesting to note that many respondents between 30 and 39 years (23.2%) of age "disagree a lot" that they receive technical support. Support for technical problems and the age are dependent because the p-value is less than 0.001 (see Table 16).

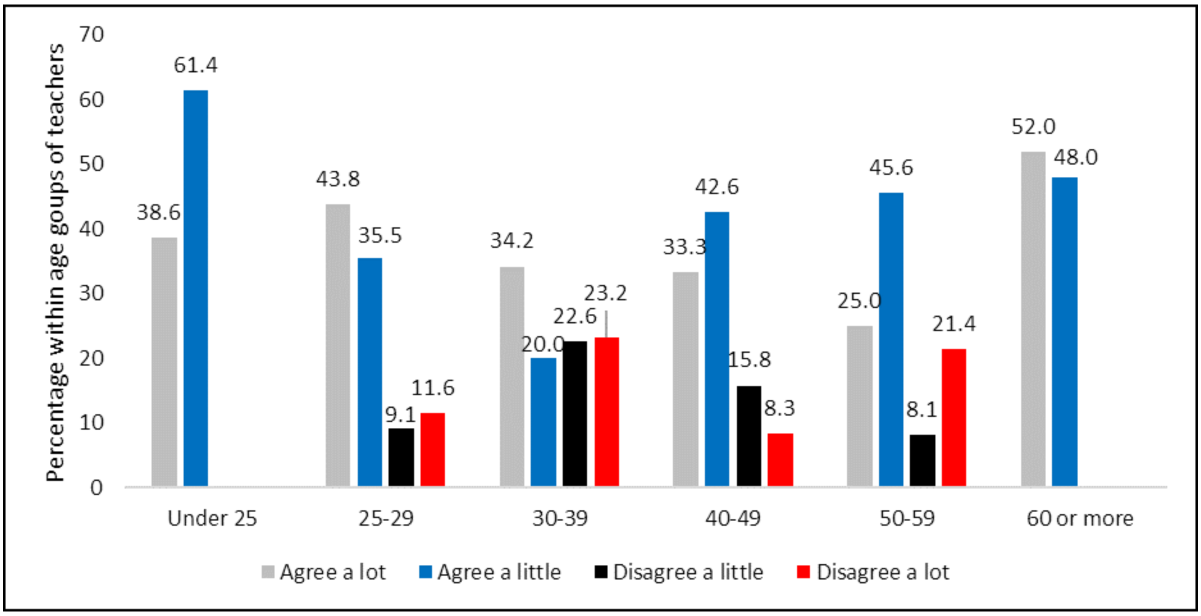

Figure 64: Support for technical problems across age

[11] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Years of teaching experience

Table 16 also shows that the support for technical problems and the years of teaching experience are dependent since the p-value is less than 0.05. It seems that it is the more experienced teachers who "agree a lot" that they receive technical support while integrating computers (see Figure 65).

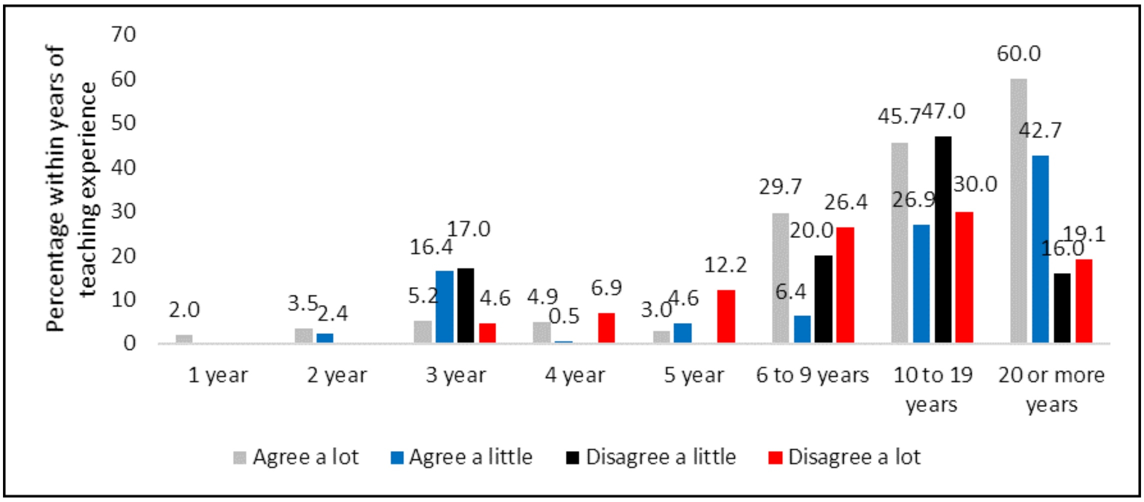

Figure 65: Support for technical problems across years teaching

Province

The respondents who are of the view that they receive support for technical problems are mostly from the Free State (66.0%); see Figure 65. Many of the respondents who "disagree a lot" that they are receiving adequate support are from Mpumalanga (51.0%); see Figure 66. There is a dependency between the teachers who receive adequate technical support and province (p-value <0.001); see Table 16.

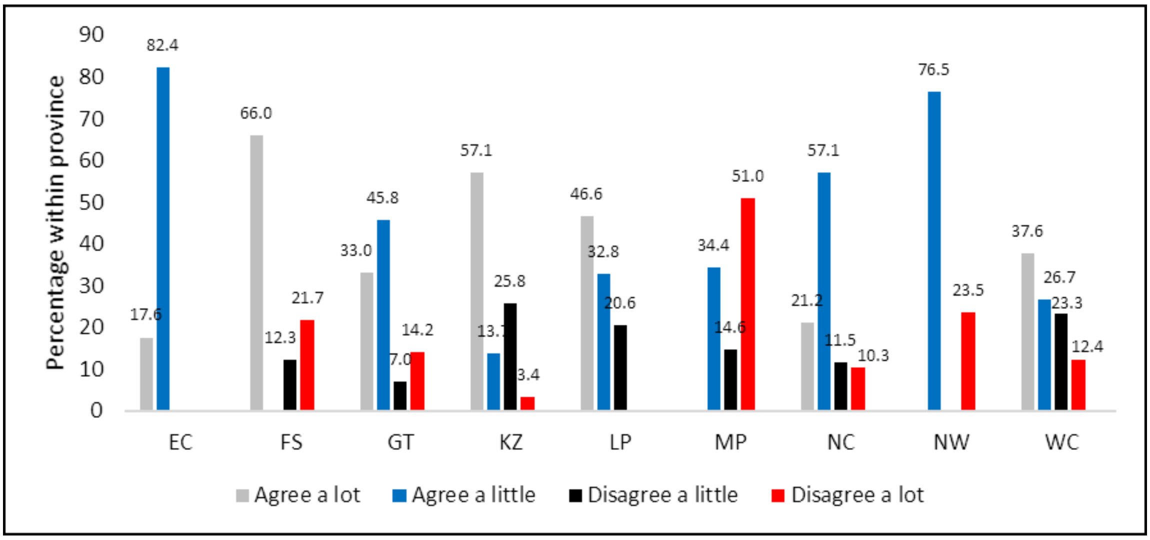

Figure 66: Support for technical problems per province

4.4.3 Adequate support for using computers

Figure 67 illustrates the views of teachers regarding adequate support when using computers in their classrooms. In total, 35.8% of the respondents are of the opinion that they do receive adequate support. On the other hand, 16.7% of teachers "disagree a lot" that they are receiving adequate support.

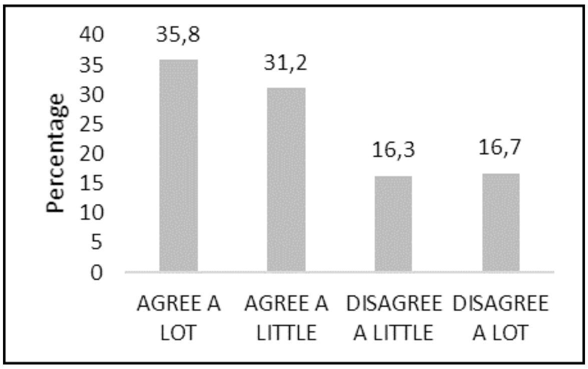

Figure 67: Adequate support

Gender

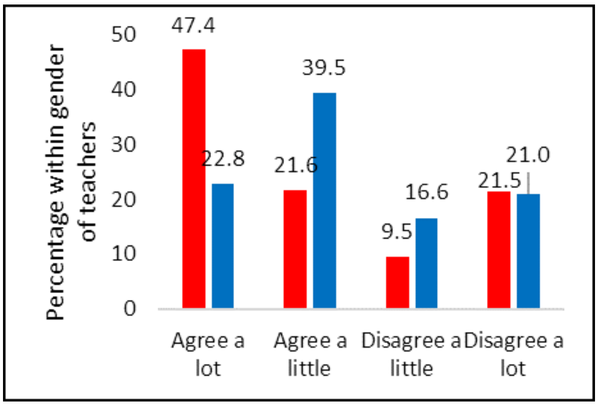

Figure 68: Adequate support across gender

A total of 47.4% females "agree a lot" that they receive adequate support while integrating computers (see Figure 68) compared to only 22.8% of males who agree to this. However, gender and receiving adequate support are not dependent, since the p-value is greater than 0.05 (see Table 17)

Table 17: Chi-square test statistics and p-values for adequate support[12]

	Test statistic	df	p-value	Outcome
Adequate support and gender	228.966	3	0.243	Independent
Adequate support and age	506.937	7	0.000	Dependent
Adequate support and years of teaching experience	710.694	21	0.000	Dependent
Adequate support and province	1999.078	24	0.000	Dependent

[12] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

Age

It is mostly the respondents 60 years and older who "agree a lot" that they are getting adequate support (see Figure 69). There is also a link between adequate support and the teachers age because it is mostly the respondents 60 years and older who "agree a lot" that they receive adequate support (see Table 17).

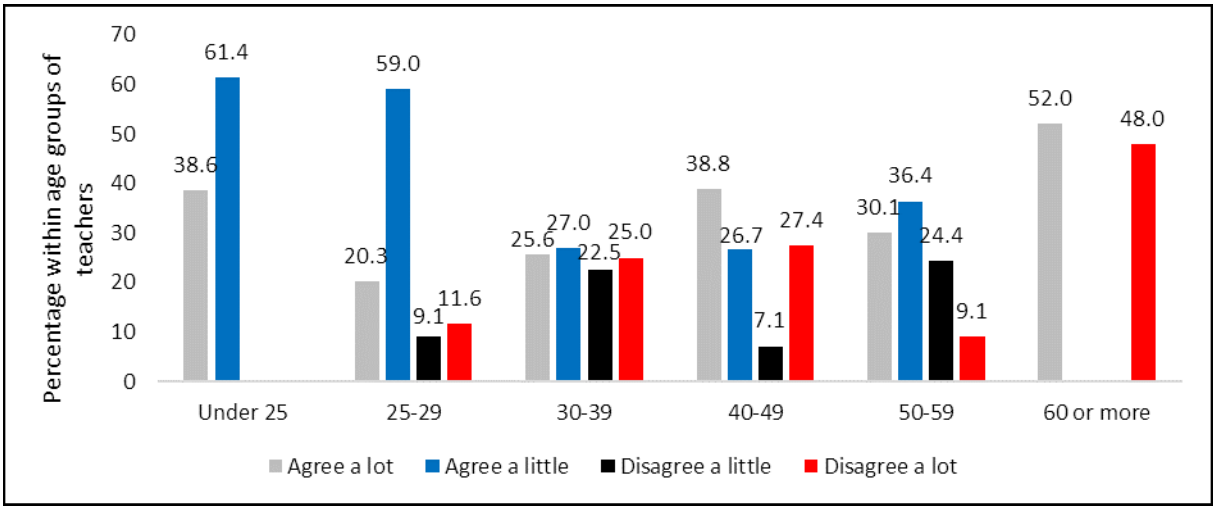

Figure 69: Adequate support across age groups

Years of teaching experience

Table 17 also shows a relationship between adequate support and the years of teaching experience for the p-value is less than 0.001. From Figure 70 it seems that it is the teachers with more experience who feel that they are not receiving adequate support.

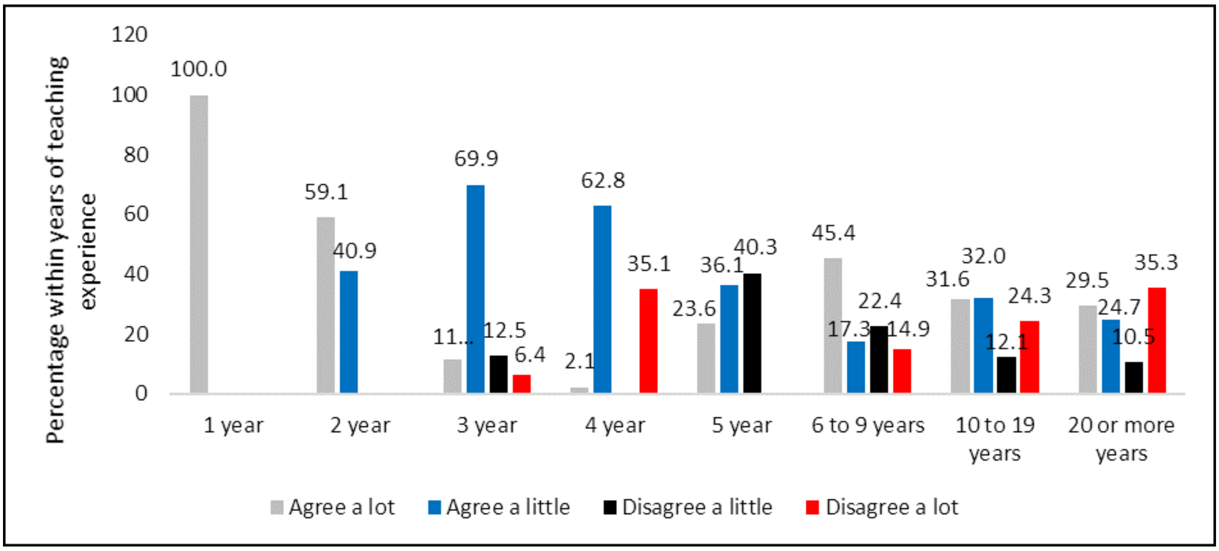

Figure 70: Adequate support across years teaching

Province

Results as shown in Figure 71 reveal that 67.6% of the respondents from KwaZulu-Natal are of the view that they get enough support when integrating computers. Most of the respondents (81.3%) who feel that they are not getting adequate support are from Mpumalanga (see Figure 71). There is a dependency between the teachers who receive adequate support when using computers in their classrooms and province (p-value <0.001); see Table 17.

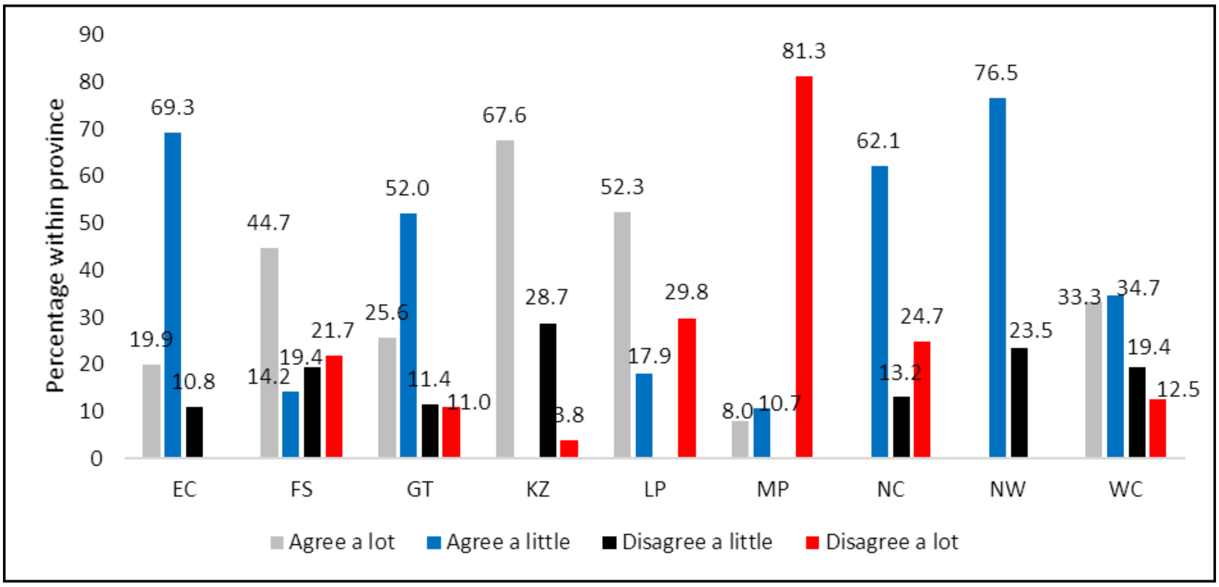

Figure 71: Adequate support per province

4.4.4 Professional development for Information Technology

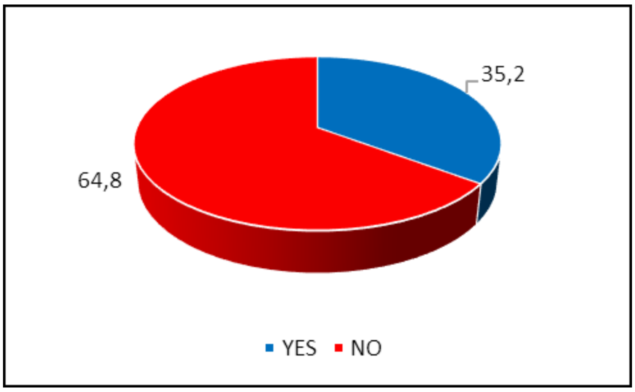

Figure 72: Professional development

Figure 72 is an illustration of professional development for integrating IT in mathematics. Overall, 35.2% of the respondents attended professional development to integrate IT in mathematics.

Gender

From Figure 73 it can be seen that the gender distribution for teachers who attended professional development for integrating IT in mathematics is almost identically distributed. This is reiterated by Table 18 that shows that these two factors are not dependent, since the p-value = 0.243 which is greater than 0.05.

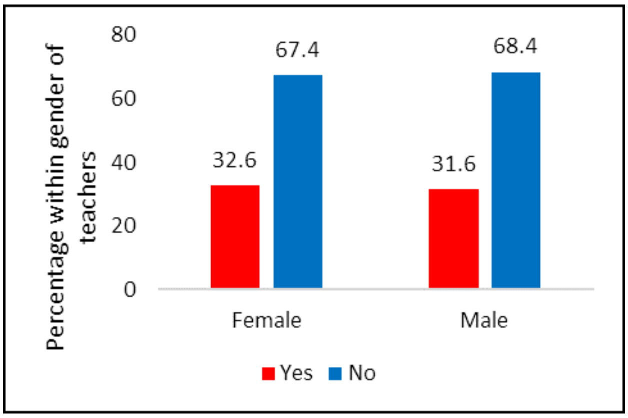

Figure 73: Professional Development for IT across gender

Table 18: Chi-square test statistics and p-values for professional development[13]

	Test statistic	df	p-value	Outcome
Professional development and gender	1.362	1	0.243	Independent
Professional development and age	444.391	5	0.000	Dependent
Professional development and years of teaching experience	217.81	7	0.000	Dependent
Professional development and province	326.099	8	0.000	Dependent

Age

It is mostly (44.4%) respondents between 30 to 39 years of age who attended professional development for IT in mathematics (see Figure 74). Furthermore it shows that it is most likely the respondents 60 years and older (85.9%) who do not attend professional development for IT integration in mathematics (see Figure 74). There is also a relationship between the teachers who attend professional development and their age since the p-value <0.001 (see Table 18).

[13] Technically, a p-value cannot equal zero. SPSS gives the p-values as 0.000 in the output, however, this is due to rounding off. Note that these p-values, reported as 0.000, are actually less than 0.001, i.e. p-value < 0.001.

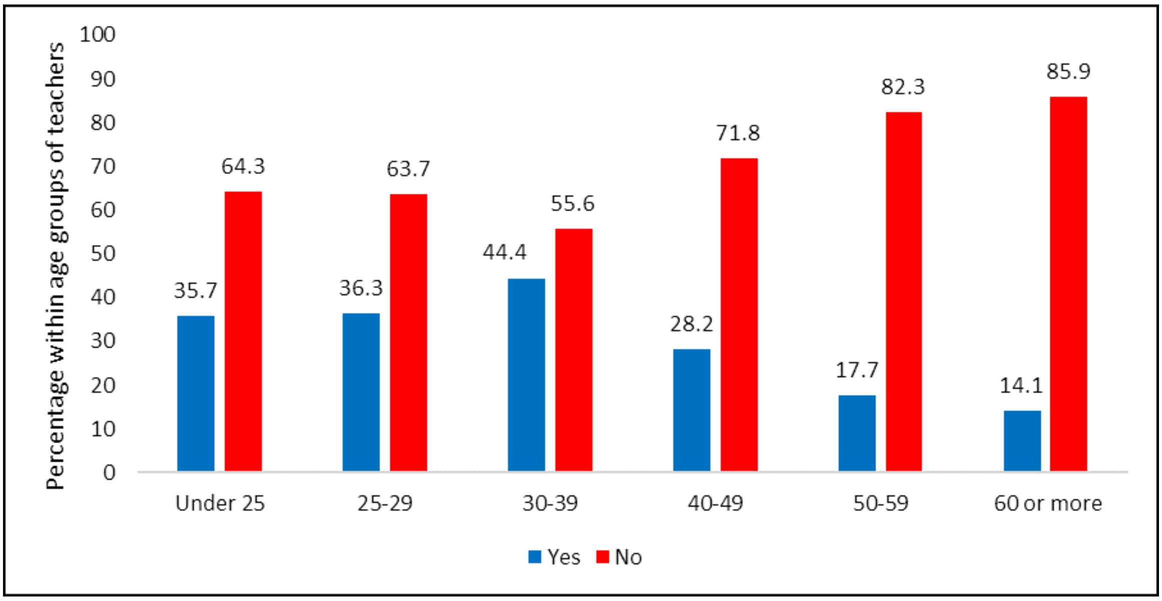

Figure 74: Professional development for IT across age groups

Years of teaching experience

Table 18 also shows that the teachers who attended professional development and their years of teaching experience are dependent because the p-value is less than 0.001. From Addendum A65.2 it seems that it is the less experienced teachers who have attended professional development, for example 44.2% of respondents with 1 years' experience answered "yes" compared to only 30% of respondents with 20 or more years' experience answering "yes" (see Figure 75).

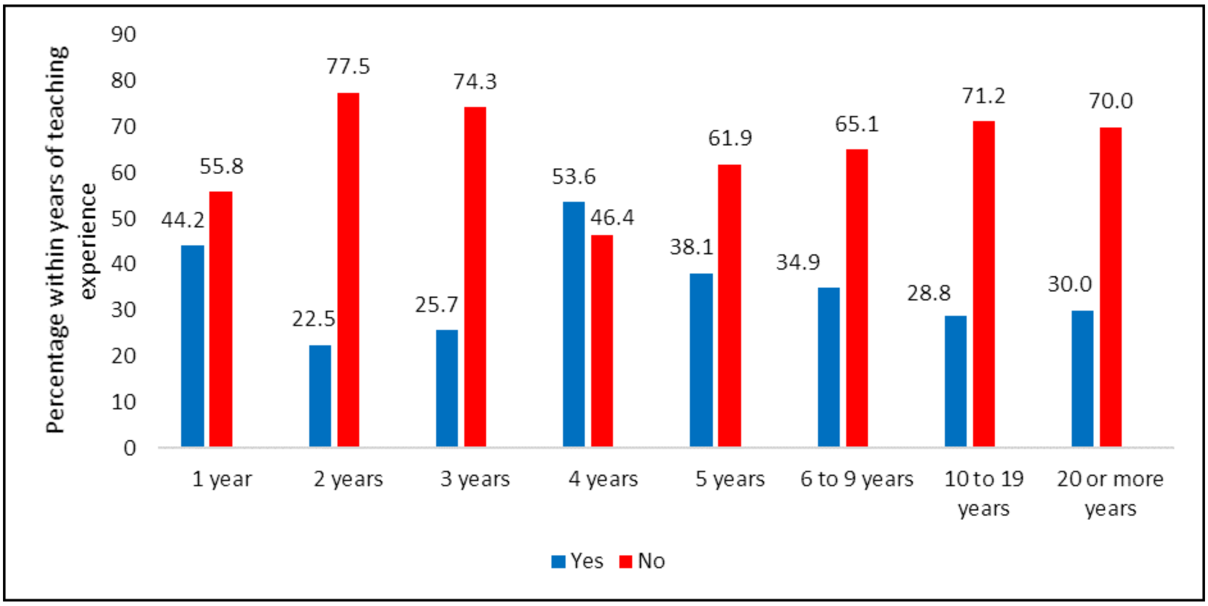

Figure 75: Professional development for IT across years teaching

Province

From Figure 76 it can be seen that 53.1% of the respondents from the Free State attended professional development for integrating IT in mathematics. Evidently, most of the respondents who did not attend professional development, were from the Eastern Cape (80.7%), followed by the Mpumalanga Province (75.2%) and the North West (74.2%). There is a dependency between the teachers who attended professional development for IT in mathematics and province (p-value <0.001) as illustrated in Table 18.

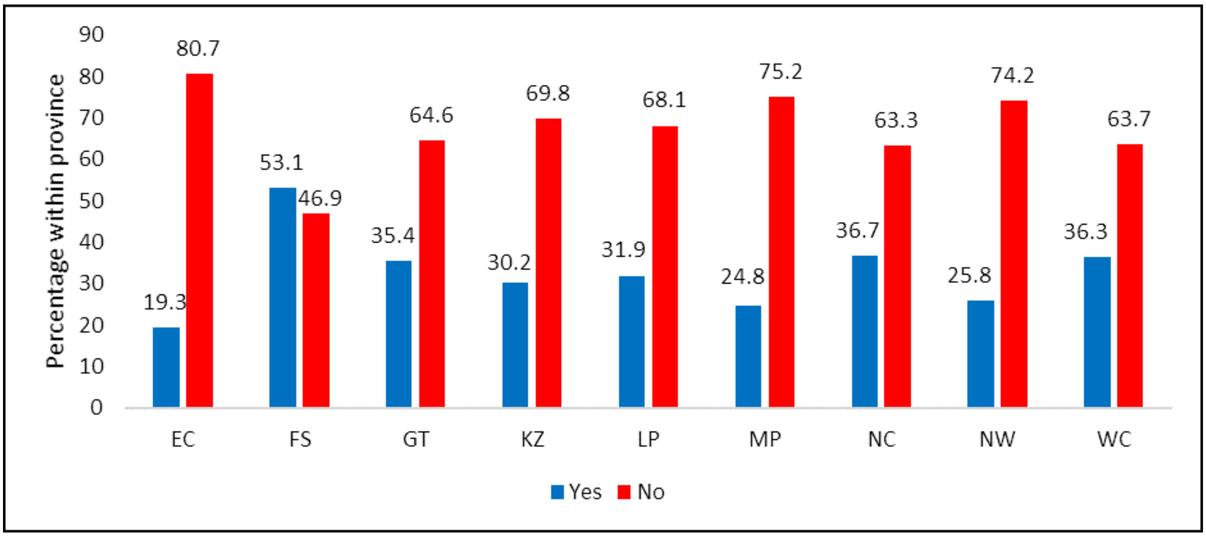

Figure 76: Professional development per province

4.5 SUMMARY OF FINDINGS

To get a better understanding of the profile of respondents in the study, the researcher investigated the age, gender, years of teaching experience, province and the major of mathematics teachers. Teachers who participated in the study were between 40 and 49 years of age. More males (57.8%) than females (42.2%) participated in this study. In total, 62.7% of teachers had at least ten years teaching experience. The current results showed that South African teachers are seemingly well educated, since more than 80% of them specialised in mathematics. The South African teachers who participated in the TIMSS 2011 study were not just well educated but they seem to be experienced as well.

The purpose of this study was to determine how South African mathematics teachers were integrating computers into their classrooms. The results of this study detected that mathematics teachers were using computers mostly for administration, with 65.3% of the respondents doing so, then for preparation (35.5% of the respondents), followed by classroom instruction (only 26.1% of the respondents). Focusing on using computers for preparation, it was found that the latter was dependent on age, years of teaching experience and province, but not on gender. In particular, teachers who make use of computers for preparation are less experienced teachers, under 25 years of age and the province with the highest percentage of doing so is the Western Cape. Focusing on using computers for administration, it was found that the latter was dependent on gender, age, years of teaching experience and province. Teachers who are most likely to use computers for administration are less experienced, female teachers, teachers under 25 years of age and the province with the highest percentage of doing so is the Western Cape. Focusing on using computers for classroom instruction, it was found that the latter is dependent on gender, age, years of teaching experience and province. Surprisingly enough, the picture now changes, where the teachers who make use of computers for classroom instruction are older males where the age group 60 and older comes out as the most prominent grouping.

This study also aimed to find out to what extent teachers were using computers in their classrooms. This was only applicable to the teachers who indicated that they used computers for classroom instruction. It is mostly teachers from KwaZulu-Natal who use computer software as basis of instruction. Teachers from the Western Cape mostly use computer software as a supplement. Teachers from Mpumalanga reported that they did not use computer software as a basis for instruction, nor as a supplement; more than 90% of teachers from Mpumalanga stated that they don't use computer software in their classrooms. The findings showed that teachers who used computers in their classroom instruction used computers to look up ideas, to do procedures, to explore concepts and to process data in mathematics.

Even though many of the teachers reported that they felt comfortable using computers, others felt that they were still in need of adequate support, as well as technical support when problems arose while using computers. It was detected that most of the teachers who were in need of technical and adequate support were from Mpumalanga since more than 80% were not comfortable using computers. As a result therefore, they were never or almost never using computers to look up ideas, to do procedures, to explore concepts and to process data in mathematics.

Another major finding of this study is that 64.8% of the mathematics teachers do not seem to attend professional development/training for integrating IT into mathematics. Many teachers especially form the Eastern Cape, Mpumalanga and the North West have not attended any professional development for IT in mathematics in the past two years (2010-2011).

There are many other interesting findings, but to summarise it concisely, we notice that many of the factors are dependent on the age, years of teaching experience and province of the teacher, however, very few are dependent on gender.

4.6 CONCLUSION

In this chapter, the results of the statistical analyses were reported. Furthermore, a summary of the findings were also provided. In the next chapter, an overview of the study and recommendations will be discussed.

CHAPTER 5

SUMMARY AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, a summary of the study as well as an attempt to answer the research questions are provided. The chapter continues with a summary of the methodology after which recommendations and suggestions for further research conclude this chapter.

5.2 AN OVERVIEW OF THE STUDY

The aim of this study was to investigate how South African mathematics teachers were integrating computers into their classrooms. The study was guided by the following main research question:

- How do South African mathematics teachers integrate computers in mathematics in their classrooms?

In order to answer the main question, the following sub-questions were explored:

- For what purpose and to what extent do mathematics teachers use computers in their profession?
- How do the mathematics teachers perceive the support they get for integrating computers in their teaching activities?
- Have these teachers recently participated in professional development in integrating IT into mathematics?

The literature review, as reported on in Chapter 2, explored mathematics education, the benefits of computer integration in mathematics, possible barriers to the integration of computers in teaching, and finally, international and national studies on computer integration in mathematics. It was established that teachers do not integrate computers due to institutional, teacher and learner level barriers. Lack of adequate and technical support seemingly hinders teachers from integrating computers in their classrooms. Themes which emerged from previous studies included for example, advantages and disadvantages of the use of computers in mathematics education. Flaws in methodology were also identified which helped to choose an appropriate framework for the study. For instance, studies in South Africa based on TIMSS 2011 focused mostly on learner performances rather than the integration of computers by South African mathematics teachers. The study was finally based on the principles of the first generation Activity Theory.

In Chapter 3, the philosophical worldview of the researcher and research methodology of the study were discussed. This study was based on the assumptions of post-positivism (Creswell, 2009). In this study, the researcher followed the position of objectivism (Howell, 2013). Since this was a SDA study, the researcher was detached from the objects in the study which ensured that the study was bias free. The study was conducted by means of a quantitative SDA using the TIMSS 2011 dataset. The study used South Africa's data which was obtained from the IEA's data repository. The dataset of the mathematics teachers from a sample of 298 schools was retrieved in SPSS format. No instruments were designed, however, questions from the TIMSS 2011 mathematics questionnaire were extracted to answer the research questions (see Chapter 3). The codebook of TIMSS 2011 was used to select the appropriate variables for this study. This step happened after the researcher familiarised herself with the methodology of TIMSS 2011. The SPSS version 23, in conjunction with IDB Analyzer version 3.0, were used to perform analysis. The rich data that were mined in this manner, was analysed using descriptive statistics, as well as Pearson two-way Chi-square tabulations. A significance level of 5% (0.05) was used for all statistical tests.

Chapter 4 reported the results of the study. As mentioned earlier, descriptive statistics were used, which included percentages that were illustrated with pie charts and bar graphs. Moreover, the Pearson two-way Chi-square tabulations were also utilised. These outputs were added to the study in Addenda in electronic form. This study did not report on factors that were independent, meaning that all the cases where the p-values were greater than 0.05 were not discussed. The result showed that respondents were mostly male teachers. Most of the teachers who participated in this study had at least 10 years teaching experience. As mentioned earlier in Chapter 4 most teachers who participated in the study were between 40 and 49 years of age. The interested reader is referred to Chapter 4 for a summary of the analysis. The analysis of the study included teacher demographics such as age, number of years teaching experience, gender and the major the teacher specialised in. An analysis regarding the purpose and extent to which teachers integrate computers were also included. Additionally, the perceptions of mathematics teachers regarding support were also included in the analysis.

5.3 ANSWERING THE RESEARCH QUESTIONS

In this section, the answers to the research questions are discussed. The focus will be on each of the sub-questions, after which the main research question will be answered.

For what purpose and to what extent do mathematics teachers use computers in their profession?

Overall, 65.3% of the respondents use computers for administration whilst only a small percentage (35.5%) used computers for preparation. The fact that more teachers are using computers for administration can be the result of the increased popularity of the software called SASAMS, which is used by schools to perform administration duties. Less than 30% of mathematics teachers indicated that they use computers for classroom instruction. Very few respondents use computer software as basis of instruction, as less than 20% of the mathematics teachers reported that they use computers software as a supplement in their classroom. However, very few teachers, mostly from the Free State seem to use computers to explore concepts, to do procedures, to look up ideas and to process data. This study found that 45.5% of the mathematics teachers are comfortable using computers. However, the minority who indicated that they felt uncomfortable using computers, were the ones who are in need of adequate training, as well as technical support. The older mathematics teachers reported that they received adequate technical support. It is worth mentioning that most of the teachers who are of the opinion that they receive adequate support are from the Free State. However the teachers from Mpumalanga were of the opinion that the support is insufficient.

Have these teachers recently participated in professional development in integrating IT into mathematics?

In total, 64.8% of the respondents did not attend professional development opportunities that focused on integrating IT into mathematics education. This observation was specifically true for teachers from the Eastern Cape and Mpumalanga. It is only a few female teachers who reported that they attended professional development for IT in mathematics. It emerged that 53.1% of the teachers who attended professional development for IT were from the Free State.

In conclusion, a large percentage of teachers from the Western Cape indicated that they used computers for preparation, administration and for classroom instruction. As mentioned in Chapter 4, 41.6% of the male teachers use computers for preparation and 64.0% use computers for classroom instruction. As mentioned earlier, this could be the result of the Khanya project. In general, it is the more experienced, and male, teachers from the Free State who used computers to explore concepts, to do procedures, to look up ideas and to process data. In particular, the teachers from the Free State attended professional development for integrating IT in mathematics. The much older teachers (60 and more) as well as female teachers, are receiving adequate support as well as technical support. Adequate support can include, for instance, pedagogical support whereas technical support refers to the need of technical staff to maintain hardware and software. Teachers from South Africa, in particular, Eastern Cape and Mpumalanga, are not attending professional development for integrating IT in mathematics. The results of the study shows that one of the main reasons why more than 70% of South African mathematics teachers are not integrating computers in their classrooms could be because they don't feel empowered enough. There is obviously a need for professional development opportunities that focus on the integration of IT into mathematics. So, **how do South African mathematics teachers integrate computers in their classrooms?** South African mathematics teachers use computers for their preparation, administration and in their classroom instruction.

5.4 RECOMMENDATIONS

The results of the study may contribute to policy formation and implementation plans. Initiatives to integrate ICTs into teaching should be implemented in provinces in particular, Mpumalanga and North West, in order for these teachers to integrate computers in their teaching. Schools should have the necessary adequate support as well as technical support to assist teachers with problems while integrating computers. Lastly, continuous professional development, designed specifically for mathematics teachers on how to use computers in their classrooms should be made a priority.

5.5 SUGGESTIONS FOR FURTHER RESEARCH

As mentioned earlier, this study was a quantitative SDA study based on TIMSS 2011 data. The nature of this study only allowed the researcher to determine how mathematics teachers are using computers in the classroom. It would be interesting to find out why the teachers are not using computers. Therefore, a study which aims at investigating teachers' beliefs or perceptions about the use of computers in the classroom, would provide the answers to why most teachers are not using computers. Furthermore, because of the unequal distribution of computers in South African schools, the researcher would suggest that future research should compare the use of computers in South African schools either by type, or geographical location. For example, it would be interesting to compare the difference in the use of computers in private, public and Dinaledi schools in South Africa, or to compare the use of computers between urban and rural schools. South Africa currently faces a crisis in mathematics education in particular the grade nine achievements (Naidu-Hoffmeester, 2015). Consequently, future research could be conducted where an international comparative study between South Africa and the top five countries in mathematics achievement are made, to see if the use of computers determine learner performance.

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ADDENDA

See attached CD.