THE NATURE OF THE RELATIONSHIP BETWEEN MATHEMATICS TEACHERS' PEDAGOGICAL BELIEFS AND THEIR USE OF EDUCATIONAL TECHNOLOGY.

By

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LIST OF ABBREVIATIONS

ICT   Information and Communication Technology

DoE   Department of Education

CAPS   Curriculum and Assessment Policy Statement

SAIDE   South African Institute for Distance Education

GDE   Gauteng Department of Education

TnETL   Tennessee EdTech Launch

OBE   Outcomes Based Education

HED   Higher Education Diploma

ABSTRACT

This qualitative study investigated the nature of the relationship between Mathematics teachers' pedagogical beliefs and their use of educational technology in the classroom. Seven teachers from a school in Gauteng, where educational technology and training is readily available, were interviewed and observed.

This study used Samuelowicz and Bain's (2001) framework to describe the dimensions and categories that encapsulate teachers' beliefs about teaching and learning. This framework set out four types of belief orientations ranging from teaching-centred beliefs to learning-centred beliefs. The interview questions, based on this framework, were used to establish the nature of teachers' pedagogical beliefs.

To determine the teachers' use of educational technology, interviews as well as classroom observations were utilised, based on aspects of technology integration in the classroom as outlined by Van Braak, Tondeur and Valcke (2004). They classified teachers as either supportive technology users or class users. Supportive teachers use educational technology for administration and preparation purposes whereas teachers that use educational technology for class use purposes use the technology interactively in their lessons to promote the learning of Mathematics.

In conclusion, it was found that teachers with teaching-centred beliefs were more likely to use educational technology for supportive purposes and teachers with learning-centred beliefs were more likely to use educational technology for class use purposes. It was also found that teachers' use of educational technology was not limited to two categories, as teachers were expected to use technology for administration purposes.

KEYWORDS

- Pedagogical

- Beliefs

- Educational

- Technology

- Teaching-centred beliefs

- Learning-centred beliefs

- Supportive technology use

- Technology class use

- Mathematics

- Technology integration

CHAPTER 1

INTRODUCTION

Technology is rapidly evolving and Information and Communication Technology (ICT) has become crucial to the "knowledge economy" (Gauteng Department of Economic Development). Learners in South Africa, as well as all over the world, are technologically-orientated and some teachers have started to integrate educational technology into their teaching in order to improve their teaching methods and remain up to date in the "knowledge economy". As a result of this increasing change, "technology integration in the classroom" has become a popular research topic (Sang, Valcke, van Braak & Tondeur, 2009; Pierce & Ball, 2009; Goos & Bennison, 2008; Chrysostomou & Mousoulides, 2009).

This chapter will outline the rationale of this study, as well as the aims and objectives and problems with integrating educational technology in South African Mathematics classrooms. The research questions as well as the methodological considerations are also discussed. In this chapter, the key terms of the study are defined and the possible contributions of the study are discussed. The chapter finishes with a summary of the structure of the dissertation.

1.1   RATIONALE

In South Africa there have been numerous attempts to supply schools with educational technology and to supply support and training to encourage technology integration in the classroom. Some of these projects include the Technologies Access Programmes, E-Schools' Network, Gauteng Online, Khanya Project, Microsoft Schools Agreement and TuxLabs (Isaacs, 2007). These projects have provided schools in South Africa that are equipped with various types of educational technology that are available for teachers' use in the classroom - especially in Mathematics. These technologies include Mathematical software like Geogebra and Geometer's Sketchpad, personal computers for every teacher, data projectors and graphing calculators.

Through my own observations around schools in Gauteng, I have noticed that some teachers, many of whom have all of these educational technologies available to them, are still not using it to improve the teaching and learning of Mathematics. This leads one to

consider that other factors beyond the supply and availability of educational technology might be influencing teachers' integration of educational technology in the Mathematics classroom.

Ertmer (2005) is of the opinion that teachers' pedagogical beliefs may explain why many teachers do not use technology, even when it is available. In her review on teachers and their technology use in the classroom, she deduced that, if teachers' pedagogical beliefs and how they influence their use of technology in the Mathematics classroom are better explained, then – ultimately - change in teachers' way of integrating educational technology in the classroom can be encouraged. Changing teachers' technology integration however, is not the focus of this study. The focus of this study is to explore and understand the nature of the relationship between teachers' pedagogical beliefs and their use of educational technology in the Mathematics classroom.

1.2   AIMS AND OBJECTIVES OF THE STUDY

Based on the rationale above, the following aims and objectives were formulated for this study. The aim of this study was to investigate the nature of the relationship between Mathematics teachers' pedagogical beliefs and their use of educational technology.

Two objectives were formulated. The first objective of the study was to determine the teachers' pedagogical beliefs and the second objective was to determine how teachers are using educational technology.

The study was inspired by the problem statement which is explained in the following section.

1.3   PROBLEM STATEMENT

In South Africa, there is a growing demand for schools to increase their use of educational technology in the classroom. The curriculum and assessment policy statement (CAPS) for Mathematics grades 10-12 (Department of Basic Education, 2011) demonstrates this growing demand by stating that the curriculum should facilitate a learner from school to

the workplace and also to help them efficiently use science and technology. To facilitate learners with this transition from school to workplace, teachers should incorporate educational technology in their daily teaching. The integration of educational technology in the classroom will not only help learners understand the Mathematical content and help them use technology in a Mathematical context but it will also help them use technology in any context - not just that which is related to Mathematics.

In January 2012 the Deputy Minister of Higher Education, Professor Hlengiwe Mkhize, stated that it is important to develop and investigate technology for use in education. Her speech was aimed at effective integration of technology in the classrooms. She suggested that teachers should become more aware of their technology use in the classroom. There is, therefore, a need for technology integration in classrooms and the government has identified this need. There are thus teachers trying to implement technology in their teaching but this does not mean that they are integrating the technology in the way the government would like it to be. Chrysostomou and Mousoulides (2009, p. 1270) found, in their study, that teachers integrated the technology into their classrooms but instead of using it as an interactive teaching tool, they would "*just use technology to do what they have always done*".

Teachers use the technology available to them, but they generally use it for "preparation and communication" rather than as a tool for instruction (Russell, Bebell, O'Dwyer, & O'Connor, 2003). Teachers are using laptops to prepare exam papers, record marks and to communicate with parents, but they are not using it as an instructional tool to help learners understand the content of Mathematics and enhance their learning experience.

1.4   RESEARCH QUESTION AND SUB-QUESTIONS

As set out in section 1.2, the study had one primary aim and it was from this aim which the primary research question originated. The primary research question for this study was:

> What is the nature of the relationship between secondary school Mathematics teachers' pedagogical beliefs and their use of educational technology in the classroom?

The secondary questions investigated were:

- What are the secondary school Mathematics teachers' pedagogical beliefs?
- How are teachers currently using educational technology in their teaching practice?

1.5   METHODOLOGICAL CONSIDERATIONS

To address the research question, a qualitative research approach was followed as the study required the analysis of words and making observations to construct a holistic picture of the topic being explored (Creswell, 2007). A case study research method was adopted, as the study included a "*systematic inquiry into an event or set of related events which aims to describe and explain the phenomenon of interest*" (Bromley, 1990, p. 302). The research paradigm followed was that of constructivism and was based on the constructivist epistemological assumption and the ontological assumption that each person constructs their own reality. Data was collected through means of interviews and classroom observations.

1.6   DEFINITION OF TERMS

Educational technology:

"*A piece of chalk and a blackboard, or even a stick and a patch of sandy ground are educational technologies in the hands of educators*" (Terry & Daryl, 2013, p. 199). Educational technology is therefore any technology used to help enhance a learner's learning experience. However, for the purpose of this study, educational technology will refer to the technology used by teachers to assist them in enhancing a learners' learning experience. Examples of these educational technologies are overhead projectors, data projectors, mathematical software, other computer software like Microsoft Office, and graphical calculators. Even a normal calculator is seen as educational technology. An elaboration on the definition of educational technology will be discussed in chapter two - the literature review.

Pedagogical Beliefs:

Pedagogical beliefs cannot be defined in one sentence and are described by Pajares (1992) as "a messy construct" because it is made up of multiple facets. Therefore, pedagogical beliefs are more comprehensively explained in chapter two, the literature review. For the purpose of this study pedagogical beliefs can be described as a teacher's pre-conceptions of the teaching and learning of Mathematics.

Class use:

When teachers use educational technology as an interactive teaching tool to improve their teaching and to enhance learners' understanding of Mathematical concepts it is known as using educational technology for class use purposes.

Supportive use:

Using educational technology for supportive use purposes suggests that teachers use the educational technology for preparation and administration and not as an interactive teaching tool.

1.7   POSSIBLE CONTRIBUTION OF THE STUDY

Currently, there is not enough empirical evidence regarding the nature of the relationship between teachers' pedagogical beliefs and their use of educational technology in the Mathematics classroom. Therefore, this study will contribute to the gap in the knowledge regarding teachers' use of educational technology in the Mathematics classroom.

As identified by Ertmer (2005), a better understanding of the nature of this relationship can also help with more effective integration of educational technology in the classroom. Teachers can identify their shortcomings with regards to their own technology integration which will help improve their teaching. Learners will be taught more effectively in the Mathematics classroom with the use of educational technology. The goal for effective use of educational technology can be met and teachers can feel more confident with regards to their teaching in the 21st century.

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1.8 SUMMARY

This chapter contains an overview of the rationale, problem statement and aims and objectives regarding the study. The research questions and sub questions were also presented, along with the working definition of educational technology for the purpose of this study. Furthermore, the possible contributions of the study were discussed. As technology is increasingly becoming part of people's daily lives, so it is expected that it become part of daily teaching. The purpose of this study was to explore the nature of the relationship between teachers' pedagogical beliefs and their use of educational technology in the Mathematics classroom. By examining this relationship, it will better provide an understanding of why many Mathematics teachers do not use educational technology as it is intended in their classrooms - even when it is readily available.

1.9 STRUCTURE OF THE DISSERTATION

This dissertation consists of five chapters. Chapter one serves as an introduction to the study as summarised above. Chapter two offers insight to the review of literature and the conceptual framework. Chapter three provides details regarding the methodology of the study describing the research paradigm, research method, data collection, data analysis as well as the methodological norms. Chapter four presents the findings of the data obtained though the classroom observations and teacher interviews. Lastly, chapter five concludes the study by describing possible topics and recommendations for future studies.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1   LITERATURE REVIEW

This study is based on the premise that every teacher has a fixed set of ideas or thoughts on teaching - their pedagogical beliefs. The purpose of this study was therefore to investigate the nature of the relationship between these pedagogical beliefs and the use of educational technology in the classroom. In this chapter, the literature review and conceptual framework is discussed.

This literature review will focus on the literature concerning educational technology, pedagogical beliefs, different types of educational technology available, the integration of educational technology in the classroom nationally and internationally, the integration of educational technology specifically in the Mathematics classroom and how pedagogical beliefs relate to educational technology.

2.1.1 INTRODUCTION

Over the past decade, the integration of educational technology in the Mathematics classroom has been widely researched. Researchers have investigated to what extent teachers integrate educational technology in their classroom (Higgins & Russell, 2003) and why they are not integrating educational technology in their classrooms (Coffland & Strickland, 2004; Goos & Bennison 2008), and the conclusions could be divided into two main aspects. The first is that there are certain contextual factors that inhibit teachers from integrating educational technology in their Mathematics classroom like a lack of time (Coffland & Strickland, 2004; Pierce & Ball, 2009; Goos & Bennison, 2008; Scrimshaw, 2004), a lack of computers and resources (Barron, Kemker, Harmes, & Kalaydjian, 2003) and a lack of training and professional development (Yates, 2002). The second is that teachers' beliefs play a certain role in their use of educational technology in their teaching (Van Braak, Tondeur, & Valcke, 2004; Sang, Valcke, Van Braak, & Tondeur, 2009; Ertmer, 2005; Ertmer, Gopalakrishnan, & Ross, 2000; Ertmer, Ottenbreit-Leftwich, Sendurur, & Sendurur, 2012).

Many studies have investigated these two aspects. They investigated what teachers' beliefs are regarding the integration of educational technology (Higgins & Russell, 2003; Sang, Valcke, van Braak & Tondeur, 2009) and the barriers that impede them from fully integrating educational technology in their classrooms (Coffland & Strickland, 2004; Goos & Bennison 2008). All these studies contribute to the body of knowledge regarding the integration of educational technology, however the nature of the relationship between more specifically pedagogical beliefs and the use of educational technology in the Mathematics classroom is an area that still needs thorough investigation (Sang, Valcke, van Braak & Tondeur, 2009; Ertmer, 2005).

2.1.2   EDUCATIONAL TECHNOLOGY

"*A piece of chalk and a blackboard, or even a stick and a patch of sandy ground are educational technologies in the hands of educators*" (Terry & Daryl, 2013, p. 199). Educational technologies can therefore be described as any tool used to help learners understand content better. Terry and Daryl (2013) further explain that educational technologies are constantly developing from previous pedagogies. Therefore, the tools that teachers use are becoming more evolved and more technologically advanced. In this section, the definition and integration of educational technology will be examined.

2.1.2.1   WHAT IS EDUCATIONAL TECHNOLOGY?

Betrus, Branch, Doughty, Molenda, Pearson, Persichitte, Rezabek, Robinson, Stoddard and Chair (2008) state that educational technology has changed over time and will continue to change over time. It consists of various elements and has different meanings to different people. Gentry (1983) defined educational technology as "*the combination of instructional, learning, developmental, managerial and other technologies as applied to the solution of educational problems*" (p. 7).

More than twenty years later Betrus, et al. (2008) defines educational technology as "…*the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources*" (p. 1).

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They divided this definition into various aspects which thoroughly explain that educational technology is a complex concept that cannot be listed as programmes or things, but rather as technology that assists teachers to enhance a learner's learning experience.

For the purpose of this study, technologically advanced educational technologies were the focus. These educational technologies include a calculator, graphical software, data projector, personal computer and overhead projector. In the following section the various educational technologies, available to teachers, will be examined.

2.1.2.2   TECHNOLOGIES THAT COULD BE UTILISED FOR EDUCATIONAL PURPOSES

Technology is becoming a prominent feature in some Mathematics classrooms, and teachers are using the technology to engage learners with Mathematical content (Moss). The role of educational technology in the classroom is to enhance the learners' learning experience in Mathematics. The National Council of Teachers of Mathematics (2008, p. 6) states the following: "*The use of technology cannot replace conceptual understanding, computational fluency, or problem-solving skills. In a balanced mathematics program, the strategic use of technology enhances mathematics teaching and learning.*" There are various types of educational technologies that teachers can utilise to enhance a learners' learning experience. One of these educational technologies is educational software. This can include mathematical dynamic software. An example of such software is GeoGebra. GeoGebra "is a multi-platform mathematics software that gives everyone the chance to experience the extraordinary insights that math makes possible" (International GeoGebra Institute, 2014). Furner (2012, p. 2013) states the following about GeoGebra:

> "*GeoGebra is a great resource and technological tool that when used in the math classroom provides a focus to:*
> * *promote technology as an essential tool for learning mathematics in the 21st century*
> * *integrate the principles and process standards with teaching the content standards*

- *provide access to all five mathematics content standards for all students*
- *support learner-centred strategies that address the diverse needs of all learners of mathematics"*

Another possible technology that could be used for educational purposes is the Internet. There are hundreds of websites that could, for example, assist teachers with online resources and lesson plans. One such site is "The National Library of Virtual Manipulatives". This website enables Mathematics teachers to share lesson plans, resources and activities, and teachers can track learners' progress on this website (Moss). YouTube, an online video website, is also a great resource as there are many educational videos that can be shown in class to illustrate a certain mathematical concept in a different way.

Some teachers are fortunate enough to be equipped with an interactive whiteboard in their classroom. An interactive whiteboard is connected to the internet and promotes interactive learning. Moss created a website especially for Mathematics, where teachers can get free resources made for the interactive whiteboard. This website is called *Interactive Whiteboard Math*.

Mobile-learning is also a new concept that is steadily settling in education. Mobile technological devices are so integrated in our daily lives that teachers should start to think about integrating these devices in their teaching (Cronje & El-Hussein, 2010). Cronje and El-Hussein (2010) claim that: "The kind of informal learning through the use of mobile devices makes it an even more potent tool of educational communication than the customary forms and modes of traditional education" (p. 15).

Apart from the educational technologies mentioned above, there are many more that teachers use in the Mathematics classroom - from calculators and tablets to data projectors. All of which, when used correctly, can engage learners in Mathematical content and increase their interest. Although some teachers make it look simple to integrate technology in their teaching, not all teachers are as successful.

2.1.2.3 *INTEGRATING EDUCATIONAL TECHNOLOGY IN THE CLASSROOM: AN INTERNATIONAL VIEW*

Integrating technology in teachers' daily teaching is a not as easy as teaching teachers to use technology. According to Dias (1999) "technology is integrated when it is used in a seamless manner to support and extend curriculum objectives and to engage students in meaningful learning. It is not something one does separately; it is part of the daily activities taking place in the classroom" (p. 11). The integration of educational technology is multi-facetted, from the acquisition of resources to teacher training and implementation workshops. The integration of technology should be based on the premise that it will expand and benefit the learners and learning environment, and as soon as that premise is established, the schools' current technology status can be examined (The Wired Teacher, 2013). Classrooms should be well equipped with educational technology before the integration thereof can be investigated. Unlike South Africa, developed countries such as the United States of America have equipped their classrooms with the necessary technology and the focus is not on supplying technology but rather on the training of teachers and learners (Mentz & Mentz, 2003). To help with this training various projects was launched, not only in the United States of America but also other countries like China and the United Kingdom.

In the United States of America, the main goal regarding technology integration is preparing learners for the actual workforce and for increasing their knowledge and skills (Lowther, Inan, Strahl, & Ross, 2008; Rutherford, 2004). The Project 2061 was launched to do just that. A report from this project called "Designs for Science Literacy" stated that computers are not the end to all curriculum problems but it can be used to transform curriculum to get closer to the actual goals they strive for.

Project RED, Revolutionising Education, (The Greaves Group, The Hayes Connection, One-to-One Institute, 2013) is another project that researches schools across the United States to determine the factors that influence teachers' decision to integrate educational technologies in their classrooms. They then use this information to come up with effective integration strategies they can share with schools.

In the developed country of China, the goal was also to supply teachers with the proper training rather than supplying schools with the educational technology (Sang, Valcke, Van

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Braak, & Tondeur, 2009). As the lack of resources was not a problem the focus was on the implementation of the educational technology.

The United Kingdom changed their curriculum in 1995 to accommodate technological subjects. The subject statements were formulated in such a way to encourage the use of technology in all aspects of life and learning (Mentz & Mentz, 2003). Thus they are more focussed on the implementation of the technology rather than the provision of it.

The focus is thus different for developed countries than for developing countries, but this does not suggest that the developed countries are more successful when it comes to technology integration. Mentz and Mentz (2003) stated the following:

> *"It is clear that the answer to the question on how to effectively introduce technology into schools lies not (only) in the provision of more money. Effectively managing the process and ensuring that teachers are trained to meet the new challenges, are key aspects in developed countries. This is also the case in developing countries."* (p. 190)

It is clear that developing countries such as South Africa should focus on the provision of educational technology, but it is just as important to also focus on the implementation after the technology has been provided. The following section will examine South Africa's attempt to integrate technology in the schools.

2.1.2.4   *SOUTH AFRICA'S ATTEMPT TO INTEGRATE EDUCATIONAL TECHNOLOGY IN SCHOOLS*

On 26 August 200, the Department of Education (DoE) released a White Paper on e-Education. The e-Education policy goal was for "every South African learner to use ICT's confidently and creatively to help develop the skills and knowledge they need to achieve personal goals and be full participants in the global community by 2013". In order to achieve this goal, many projects were employed by various different institutions.

One of the first projects to be run is the E-schools' Network in the Western Cape. This project started in 1993 with the main focus on the importance of email in schools. This service provided teachers and learners with an email mailbox for less than R 1 000 per year

in 1993. Currently the project is still underway and is only charging schools a fee of R1250 per annum (ESN, 2015).

Another project run in the Western Cape is the Khanya Project (van Wyk, 2007). This project was established in April 2001 and supplied schools with what they needed in order for the teachers to deliver curriculum material through the effective use of ICT. The Western Cape Education Department (2009) stated the following.

> *"One of the purposes of the Khanya project is to narrow the digital divide by placing information and communication technologies (ICT) and audiovisual technologies (AVT) in disadvantaged schools. These technologies are very effective in helping learners to develop the mindset they need for the 21st century – the knowledge, skills, values and attitudes one needs to become successful, contributing citizens. These are:*
>
> - *A high degree of literacy and numeracy*
> - *Problem solving skills*
> - *Critical, flexible and creative thinking*
> - *An understanding of the global environment*
> - *Responsibility for oneself and sound ethical standards*
> - *Enthusiasm for lifelong learning"*

Although this project has won numerous awards for education and development and is known internationally for its success, it came to an end in March 2012.

A project run throughout South Africa was the Telkom 1000 schools project. This project started in 1998 and aimed at providing 1000 schools in South Africa with internet access. Telkom's project was completed by 2000 and had a contract with SchoolNet SA to provide training to the teachers to use ICT as effective learning tools between 1999 and 2000 (SchoolNet SA, 2014). The South African Institute for Distance Education (SAIDE) evaluated this project and found that teachers had problems implementing the ICT's as they were not competent enough to integrate the ICT's (Siluma, 2001).

Gauteng Online is another project, launched in 2000, which aimed to supply all public schools in the province with an ICT laboratory with at least 25 computers. This enabled

teachers and learners to have access to many more resources and it helped bridge the digital divide. Alongside the computer laboratory plans were in place to supply each learner with an email address and access to internet (Dagada, 2009). An educational portal was also established in order to encourage learners to look for additional information and share ideas with friends.

> *"According to GautengOnline, the project also has educator development programmes focusing on equipping educators with the following: increased proficiency in information and communication technology (1CT); greater knowledge of educational ICT and content mastery; a greater understanding of how learners can benefit from ICT; increased reflection and metacognition while working with ICT; and improved ability to engage in practices that lead to new ways of thinking, understanding, constructing knowledge and communicating."* (Dagada, 2009)

This project was aimed at schools with a lower socio-economic status, and therefore, many other factors have to be considered when regarding the success of this project. Overall, the project reports enthusiastic educators that feel confident in using the ICT's although observational reports state that they are not using the ICT to its full potential (Dagada, 2009). Even though successful results were communicated by the GautengOnline administrators the Democratic Alliance (DA) called for a termination of the GautengOnline contract in 2012 after a financial audit (Serrao, 2012). The audit found numerous problems - from low security and maintenance measures to the centres being offline in most schools and teachers and learners not being supplied with e-mail addresses.

Along with these, there are 31 more projects that were launched in 2007 (Isaacs, 2007), all striving towards the goal of making technology more accessible at schools. South Africa therefore has made many plans and is in the process of supplying schools with educational technology and training, even though all were not successful.

The question therefore remains - if the technology and training is being supplied then why isn't the integration of educational technology more successful? Burger (2014) stated the following:

> *"... public initiatives, such as the costly and ineffective Gauteng Online project and a plethora of private initiatives have failed to make a long-*

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lasting impact on the use of electronic media and technologies at schools,
mainly owing to a focus on technologies and a lack of sustained support for
ICT in education initiatives."

The failure of so many of South African projects can therefore be attributed to the lack of continuous support and training. Other factors, such as a teachers' pedagogical beliefs, have not even been considered when investigation the integration of educational technology in the classroom. The integration of educational technology, specifically in the Mathematics classroom, has also not been thoroughly investigated. This will be discussed in the following section.

2.1.2.5 *INTEGRATING EDUCATIONAL TECHNOLOGY IN THE MATHEMATICS CLASSROOM*

Integrating educational technology in teaching is not always as seamless as one might think, especially in the Mathematics classroom, but it has been seen as an important part of Mathematics education. Franz and Hopper (2007) believe in the importance of educational technology in Mathematics and state that:

> *"When students are freed to explore math through technology and as a result*
> *not confined to paper and pencil tasks, problems that are easy to manipulate,*
> *or workable data sets, they are able to explore the rich math present in real*
> *world math modelling. By providing a technology-rich classroom, student*
> *work is no longer limited to simple symbolic manipulation. Instead, students*
> *can interact with complex, real-world problems that enhance their*
> *understanding and pique their interest in school mathematics."* (p. 1)

In a paper prepared for Texas Instruments by the Centre for Technology in learning (2007), they state that using educational technology in the Mathematics classroom not only eliminates wasted time on difficult computations but also introduces Mathematics in a different way – one that helps the learner understand the content better.

But not all Mathematics teachers hold the same view. Teachers with traditional beliefs may feel that, by using educational technology, learners are not learning basic computation skills

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(Haciomeroglu, Bu, & Haciomeroglu, 2010). Consequently, educational technology will not simply be openly adopted by all teachers hence the implementation of projects to see whether proper training will help alleviate this problem.

Lowther et al (2008) investigated just such a project. The project was called the Tennessee EdTech Launch (TnETL) and they aimed to train teachers to use educational technology as an integrated tool to create learning-centred classrooms. The idea was to get learners involved with the technology, this way they can develop critical thinking skills and help develop skills that will help them increase their performance in the modern world. Lowther et al (2008) investigated the effectiveness of this project by doing quasi-experimental research. The study found that learners undergoing the project did better in Mathematics than in the control group. Trained teachers can therefore achieve much higher success when it comes to integrating educational technology in the Mathematics classroom. It did not mention any results with regards to teachers with more traditional beliefs and whether they were more susceptible to the idea of technology integration after they had more training.

Daugherty and Wicklein's (1993) study about teachers' perspective about Mathematics teaching revealed that teachers, who are exemplary technology users in the Mathematics classroom, felt that it is essential to integrate technology into the Mathematics classroom. These teachers felt that educational technology provided a platform for mathematical discovery and problem solving activities.

In South Africa the studies on the use of educational technology were mainly focussed around the use of Geometric software when teaching Euclidian Geometry (de Villiers, 2004; Stols, Mji, & Wessels, 2008; Govender, 2011). One of these studies was by Stols, Mji and Wessels (2008, p. 15), where they investigated the "advantages of utilising technology to enhance teachers' instructional activities". This study revealed that the teachers' understanding of identical geometric concepts improved when the Geometers' Sketchpad was used to explain the concepts.

Another South African study was done by Kriek and Stols (2011). They investigated whether teachers' beliefs influenced their use and intention of using mathematical software in their teaching. Their study was based on the theory of planned behaviour, the technology acceptance model and the innovation diffusion theory. They explored these theories with

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relations to dynamic geometric software and "… found that beliefs about the perceived usefulness and beliefs about their level of technological proficiency are the most important predictors of teachers' intended and actual usage of the software." (Kriek & Stols, 2011, p. 137)

Studies have therefore been done on educational technology in the Mathematics classroom and there are teachers for and against the notion. The discussion will continue by exploring what the literature says about the levels of technology integration, the types of pedagogical beliefs and influence of a teacher's pedagogical beliefs on their technology use in the classroom.

2.1.2.6   LEVELS OF TECHNOLOGY INTEGRATION

Educational technology can be integrated and used in many different ways in the classroom. Researchers have explored these different uses of educational technology to some extent. Rutherford (2004, p. 150) stated the following:

> *"… questions remain about the degree to which schools have yet to exploit the potential of computers for transforming instruction. Computers have helped teachers and students do somewhat better pretty much what they were doing before. … But there may be more to the modest impact of computers on K-12 teaching than disinterest in radical change. It may be due, at least in part, to the general failure of educators to realize that the computer revolution has made possible a revolution in teaching and learning."*

As Rutherford states, many teachers are making use of educational technology but merely for administrative purposes like test preparation, keeping learners' record sheets and keeping record of meetings and parent communication (Sang, Valcke, Van Braak, & Tondeur, 2009; Palak & Walls, 2009). Other teachers use educational technology for the purpose of presenting their lessons by means of a PowerPoint presentation (Palak & Walls, 2009; Güven, Akkan, & Cakiroglu, 2009; Russell, Bebell, O'Dwyer, & O'Connor, 2003). It has also been found that some teachers use educational technology to teach the learners technological skills like using a scientific calculator or drawing accurate graphs and tables

or even just verifying results (Haciomeroglu, Bu, & Haciomeroglu, 2010; Palak & Walls, 2009; Güven, Akkan, & Cakiroglu, 2009). There are, however, only a few teachers that use the educational technology for the purpose of increasing learner understanding, developing higher order problem solving skills and promoting an interactive environment where learners are stimulated on various intellectual levels (Palak & Walls, 2009) or as Rutherford states, revolutionising teaching and learning.

Van Braak, Tondeur and Valcke (2004) therefore identified two categories of technology users: supportive users and class users. "Class use" refers to teachers using the various available educational technologies to support interactive lessons to promote a deeper understanding of the content. It also involves teaching interactively with the educational technology to promote learner-computer interaction. "Supportive use" refers to teachers using technology for the main purpose of administration and preparation.

Supportive use of educational technology

As South Africa is expanding, more schools are being equipped with educational technology to enhance teaching. In 2007 it was reported that 50.9% of South African schools are equipped with computers (Isaacs, 2007). It is therefore difficult to comprehend that these educational technologies are not used for this purpose, but rather it is being used for preparation and administrative purposes. It is, of course, an improvement if teachers can use the educational technology in this way but is also a disappointment to know that educational technology holds so much more potential.

Russell, Bebell, O'Dwyer and O'Connor (2003, p. 301) did a survey in the United States of America in Massachusetts. They found the following six categories of technology use:

- *"Teacher use of technology for preparation*
- *Teacher use of technology for delivery*
- *Teacher-directed student use of technology*
- *Teacher use of technology for special education and accommodation*
- *Teacher use of e-mail*
- *Teacher use of technology for recording grades"*

They found that teachers mainly use educational technology for preparation, e-mail, delivery and student-use. All of these are underpinned by a teaching-centred belief system as these activities do not support the acquisition of higher order problem-solving skills.

Class use of educational technology

According to Becker and Riel (2000) educational technology can be used in exceptional ways if the teachers use it correctly. This type of educational technology use can be described as class use. This refers to teachers using educational technology to aid their teaching and to develop learners' understanding of their subject.

Class use refers to teachers using the educational technology they have to their disposal to extend a learner's "involvement in cognitively challenging tasks where computers are tools used to achieve greater outcomes of students communicating, thinking, producing and presenting their ideas" (Becker & Riel, 2000, p. 35).

It can therefore be concluded that educational technology can be used on two different levels; for class use purposes or for supportive use purposes (Samuelowicz & Bain, 2001).

2.1.3 *PEDAGOGICAL BELIEFS*

2.1.3.1 *DEFINING BELIEFS*

According to Österholm (2010), the act of defining beliefs is very complex. Österholm (2010) investigated the various definitions found in the literature for beliefs, and questioned whether the concept of beliefs is necesary. He found that there was no clear difference between knowledge and beliefs and that the concept of beliefs was merely a tool to point out a subject that a person claimed to have a belief about.

Pajares (1992) also found beliefs to be a "messy construct". He focussed on pedagogical beliefs, rather than just beliefs in general, and found that every mathematics teacher comes to class with a pre-conceived notion of how Mathematics should be taught. This belief system of the teaching and learning of Mathematics can be described as a teacher's pedagogical beliefs (Handal, 2003). Pajares (1992) stated that *"all teachers hold beliefs,*

however defined and labelled, about their work, their students, their subject matter, and their roles and responsibilities…"(p. 314).

However difficult defining pedagogical beliefs might be, Pajares (1992, p. 325-326) identified multiple facets that relate to the formation of a teacher's pedagogical beliefs. Not all of these facets relate to this study and therefore only eight of these facets has been selected and reconstructed to represent a mathematical teacher's pedagogical beliefs.

    i.   The beliefs an individual hold are formed early in life and is sustained throughout. It is possible to contradict these beliefs with information that is scientifically proven but the individual will most likely reject this information because it does not align with their beliefs.

    ii.   An individual formulates a belief system by means of cultural transmission. Bisin and Verdier (2005) states that cultural transmission are social interactions passed down by generations.

    iii.   Individuals adapt their belief systems to make the world around them more understandable.

    iv.   Knowledge and beliefs are intertwined, beliefs filter through to explain new phenomena.

    v.   Beliefs stem from thought processes, but beliefs distorts and reshapes what you are thinking.

    vi.   Beliefs are organized according to priority in relationship to other beliefs. Beliefs are therefore understood by comparing them with other beliefs (educational beliefs will form in connection with already existing beliefs.)

    vii.   The earlier a belief is acquired the harder it is to change whereas newly acquired beliefs are more easily altered. Therefore changes in beliefs in adults are rare.

    viii.   Beliefs play a role in the way an individual will act and react to certain situations.

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These multiple facets that influence/form a teacher's beliefs are the same facets that influenced Samuelowicz and Bain (2001) when they developed their framework to describe the different types of pedagogical beliefs a teacher might have. These pedagogical beliefs are described in the section that follows.

2.1.3.2 PEDAGOGICAL BELIEFS

Samuelowicz and Bain (2001) developed their own framework to identify a teacher's pedagogical beliefs. They classified teachers' pedagogical beliefs in four main categories. These categories range from teaching-centred beliefs, teaching-centred beliefs that focus on learning, learning-centred beliefs that focus on teaching learning-centred beliefs. Other researchers have also investigated pedagogical beliefs and they will be discussed further in the following pages.

Teaching-centred beliefs

Teachers with a behaviouristic paradigm follow teaching approaches that can be described as teaching-centred approaches to teaching and will fall within the teaching-centred orientation. Crawford (1999) explains this type of teaching as follows:

> *"Learning is considered to have taken place only if there is an observable change in behaviour; learners are encouraged by rewards and inhibited by punishments."*

Therefore, teachers with teaching-centred beliefs will present the content they teach to the learners and expect the learners to learn what has been taught. Learners are expected to learn certain facts, and only after are they able to reproduce the facts have they learned. Teaching-centred approaches do not allow for self-discovery or construction of knowledge, rather the acquiring of knowledge by reproducing what was taught.

In terms of educational technology use, Becker and Riel (2000) reported that teachers with a teaching-centred belief system did use educational technology but only for lower order skills and not as an interactive tool to promote understanding. Thus a teacher might make use of graphical calculator to demonstrate a problem but would not allow the learners to use that calculator to discover a solution for themselves.

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In a study done by Haciomerglu, Bu and Haciomerglu (2010) they found that teachers stated explicitly that educational technology should only be used in collaboration with traditional teaching methods as the educational technology might obstruct the learners' understanding of Mathematics as it influences their "mastery of basic skills and procedures". Pierce and Ball (2009) found the same negative attitude towards the use of educational technology in the Mathematics classroom among teachers with traditional beliefs[1]. Güven, Akken and Cakiroglu (2009) also reported a resistance against educational technology integration amongst teachers with traditional beliefs. Therefore, teachers with traditional beliefs will make use of behaviouristic pen and paper exercises as they believe it is the best way to learn Mathematics. They will focus on unassisted computation and rote memorisation exercises.

In South Africa, before Outcomes Based Education (OBE) was instated, almost all the teachers had traditional beliefs. Jansen (1998, p. 326) quotes Vithal's (1997) view on Mathematics education in South Africa: "… there is arguably a tradition of defining narrow behavioural objectives derived from the content mathematics teachers are expected to teach."

These beliefs were formed based on what they were taught and therefore there are many teachers that still have teaching-centred beliefs even after OBE was implemented. These teachers believe that rote memorisation of basic mathematical concepts is the base for good mathematical skills. Integrating educational technology in their teaching is therefore also more difficult for these teachers.

Learning-centred beliefs

Opposite to teaching-centred beliefs are learning-centred beliefs. This approach is mainly seen as an approach followed by people with a constructivism paradigm and will fall within the learning-centred orientation. Crawford (1999) explains it as follows:

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[1] Traditional beliefs here have the same meaning as teaching-centred beliefs. It has different names in different countries.

"Learners create their own knowledge and understanding through active engagement with realistic tasks in authentic contexts using actual tools, and as there are many learners, there will be a multiplicity of understandings, though these will be moderated through social discourse." (p.53)

By using a learning-centred teaching approach, the teacher therefore guides the learners in such a way that they are able to construct their own knowledge. This approach is therefore favourable to a learning-centred belief system as the learner plays the biggest part in his/her learning experience (Cullen & Davis). Incorporating technology into such an approach therefore requires the technology to assist in discovery practices.

Chrysostomou and Mousoulides (2009) did an intensive study on teachers' willingness to incorporate educational technology in the Mathematics classroom. The teachers in this study responded favourably to educational technology integration. These teachers all mentioned the importance of developing higher order problem solving skills, a key characteristic of a learning-centred belief system. Becker and Riel (2000) also found that teachers with a learning-centred belief system did use educational technology exemplary, they used in such a way to promote higher order thinking skills and a deeper understanding of the content.

On the other hand, Palak and Walls (2009) found that using technology to increasing higher order thinking was rare under even those teachers with learning-centred beliefs. They found that the teachers that used the most educational technology in the classroom were teachers with learning-centred belief systems but even these teachers struggled to use the educational technology to promote higher order thinking skills. Lowther, Inan, Strahl and Ross (2008) came to a similar conclusion and stated that learner-centred classrooms lead to more effective use of educational technology.

This is one of South Africa's main concerns, as we have changed our curriculum to suit learning-centred beliefs. One of the main goals in the Mathematics curriculum is to promote critical thinking rather than rote memorisation (Department of Basic Education, 2011). Teachers with teaching-centred beliefs will therefore struggle to integrate such a curriculum as their beliefs will influence their teaching practise.

2.1.3.3   PEDAGOGICAL BELIEFS AND EDUCATIONAL TECHNOLOGY

Palak and Walls (2009, p. 417) identified a relationship "between teachers' beliefs and their instructional technology practices" and found the following: teachers use educational technology mainly for administrative work and preparation. When teachers use educational technology they do not use it for student centred practices and teachers in technology-rich schools use educational technology to support teacher centred instructional practices. Ertmer (2005) also recognized this relationship and recommended in her study that more studies be done on the ability to change teachers' beliefs as she believes that when teachers' beliefs about using technology change, integration will be much more efficient. It seems that, if we understand why teachers are not fully integrating educational technology in the classroom, we can adapt our approach to the integration of educational technology to promote change in teachers' teaching practice with regards to educational technology integration, especially in the Mathematics classroom.

Ertmer (2006) did a comprehensive study whereby she divided teachers' willingness to change into two categories - first order change and second order change. She stated that first order change has to do with altering practise without it having an effect on standing structures, whereas second order change has to do with changing core pedagogical beliefs. This study explains why teachers are not using educational technology for the goal of enhancing a learners' learning experience as it goes against their core Mathematical pedagogical beliefs.

It is believed that certain belief systems support certain teaching strategies. According to Hermans, Tondeur, van Braak and Valcke (2008) and Woolley, Benjamin and Woolley (2004) teachers with teaching-centred beliefs mainly follow behaviouristic paradigms which in turn lead them toward teaching-centred practises. Teachers with learning-centred beliefs conversely follow constructivist paradigms and lead them to focus of learning-centred practises.

2.2   THE CONCEPTUAL FRAMEWORK

The conceptual framework for this study consists of two different frameworks. The first framework was formed by Samuelowicz and Bain's (2001) on the formation of pedagogical

beliefs, and the second framework was formed by van Braak, Tondeur and Valcke (2004) to distinguish between the different types of uses for educational technology. These frameworks will be thoroughly explained in the section that follows.

2.2.1 TEACHERS' PEDAGOGICAL BELIEFS

As discussed in the literature review, pedagogical beliefs are a complex concept. Each teacher steps into a classroom with a pre-conceived notion of how their subject should be taught and learned. In Mathematics, in particular, teachers form very strong pedagogical beliefs in terms of how mathematical skills and knowledge should be acquired and therefore strongly influence the way they teach Mathematics (Güven, Akkan, & Cakiroglu, 2009).

In order to accurately assess a teacher's pedagogical beliefs Samuelowicz and Bain (2001) simplified the concept of pedagogical beliefs by categorising the different types of beliefs. It is on this simplified framework that this study was based. As in Samuelowicz and Bain's (2001) framework, the pedagogical beliefs were divided into 4 beliefs orientations. These belief orientations are teaching-centred belief, teaching-centred belief that focuses on learning, learning-centred belief that focuses on teaching and learning-centred belief. These belief orientations are distinguished by the belief dimensions. These beliefs as set out by Samuelowicz and Bain's (2001, p. 306-307) are as follows:

- Desired learning outcomes
- Expected use of knowledge
- Responsibility for organising or transforming knowledge
- Nature of knowledge
- Learners' existing conceptions
- Teacher-learners interaction
- Control of content
- Professional development
- Interest motivation

A teacher's belief dimension therefore depends on their beliefs in each of the belief orientations. An adapted figure of Samuelowicz and Bain's (2001) framework can be seen below.

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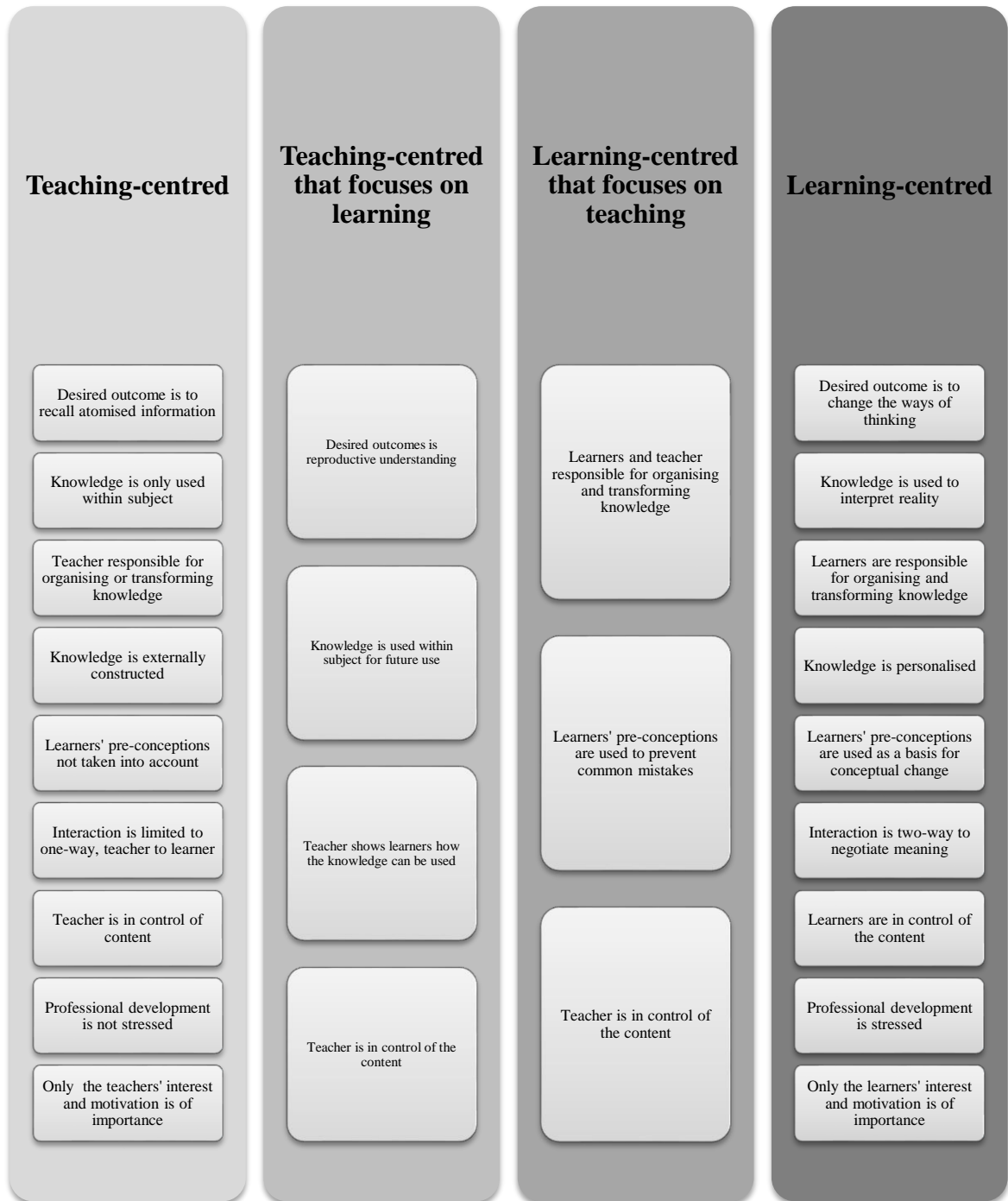| Teaching-centred	Teaching-centred that focuses on learning	Learning-centred that focuses on teaching	Learning-centred
Desired outcome is to recall atomised information	Desired outcomes is reproductive understanding	Learners and teacher responsible for organising and transforming knowledge	Desired outcome is to change the ways of thinking
Knowledge is only used within subject	Knowledge is used within subject for future use	Learners' pre-conceptions are used to prevent common mistakes	Knowledge is used to interpret reality
Teacher responsible for organising or transforming knowledge	Teacher shows learners how the knowledge can be used	Teacher is in control of the content	Learners are responsible for organising and transforming knowledge
Knowledge is externally constructed	Teacher is in control of the content		Knowledge is personalised
Learners' pre-conceptions not taken into account			Learners' pre-conceptions are used as a basis for conceptual change
Interaction is limited to one-way, teacher to learner			Interaction is two-way to negotiate meaning
Teacher is in control of content			Learners are in control of the content
Professional development is not stressed			Professional development is stressed
Only the teachers' interest and motivation is of importance			Only the learners' interest and motivation is of importance

Figure 1: Different belief-orientations (adapted from Samuelowicz and Bain (2001)

As this framework was not subject specific, it had to be interpreted in a mathematical context. Each belief orientation and belief dimension will therefore be explained within the context of Mathematics in the section that follows.

2.2.1.1 PEDAGOGICAL BELIEF ORIENTATIONS IN THE CONTEXT OF MATHEMATICS

For this study the framework by Samuelowicz and Bain (2001) had to be interpreted in the context of the Mathematics teacher, hence the discussion of the four belief dimensions in the section that follows.

Teaching-centred beliefs

A teacher with teaching-centred beliefs will therefore believe that Mathematics is learnt by "recalling atomised information and knowledge is externally constructed" (Samuelowicz & Bain, 2001, p. 310). A teacher with these beliefs will therefore present the learners with information which they would want the learners to memorised and recall. This also means that what the learners learn solely depends on the teacher's input. This teacher also believes that Mathematics will be applied in subject specific contexts only. When teaching Mathematics, the teacher is responsible for the organisation and transformation of the content and the teacher will be the only one transferring information in the class. These teachers will also believe that only the teachers' motivation and interest is important when teaching and that a learner's pre-conceptions do not need to be taken into account when teaching.

Teaching-centred beliefs that focus on learning

A teacher with teaching-centred beliefs that focuses on learning differs from teachers with teaching-centred beliefs in that a teacher would show the learners how Mathematics can be used within the subject in future. So they would focus on showing how Mathematics can be applied in Engineering and Architecture but not in field like that is not a mathematical field like Business Economics, although mathematics is used in that field. They also believe that the desired outcomes are "reproductive understanding" (learning by means of knowing facts and procedures that can be applied in real life) and not recalling memorised information.

Learning-centred beliefs

A teacher with learning-centred beliefs will teach Mathematics in order to "change a learner's way of thinking" (Samuelowicz & Bain, 2001, p. 310). They will teach so the learners can use Mathematics to interpret reality. Learners will be in control of the content

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and will be responsible for organising and transforming their Mathematical knowledge. This means that the teacher will only use the prescribed plan as a guideline but in practise the learners determine which topics should be done and for how long. If the teacher thinks the learners need more attention in a certain topic then much more time will be allocated towards that topic. A learning-centred teacher will encourage two-way communication between the teacher and learner to "negotiate the meaning of the content" (Samuelowicz & Bain, 2001, p. 311). In this way the teacher encourages the learners to make the content their own. The teacher will also consider a learner's pre-conceptions about Mathematics and use it as a basis for "conceptual change (Samuelowicz & Bain, 2001, p. 311)".

Learning-centred beliefs that focus on teaching

Teachers who have learning-centred beliefs that focus on teaching differ from teachers with learning-centred beliefs in the fact that they believe that the teacher and learner is responsible for "transforming and organising mathematical knowledge" (Samuelowicz & Bain, 2001, p. 310). A teacher with these beliefs will therefore allocate more time towards a topic if it is found that the learners are struggling but the teacher will be aware of the time constrictions and know that time will then have to be taken away from another topic at some other stage. These teachers will also take learners' pre-conceptions into account but rather to prevent learners from repeating usual mathematical errors. These teachers also believe that the teacher is in control of the content and not the learner.

2.2.1.2   PEDAGOGICAL BELIEF DIMENSIONS IN THE CONTEXT OF MATHEMATICS

The belief dimensions as set out by Samuelowicz and Bain (2001) were also not subject specific thus these dimensions were also interpreted, as follows, in the context of Mathematics.

Desired learning outcomes

In Mathematics the teachers could expect the learners to have one of three desired learning outcomes. The first is to recall memorised mathematical knowledge like reciting times tables or knowing area formulae off by heart. The second outcome is to reproduce mathematical content because they understand what they learnt, for example demonstrating

their times tables by grouping same coloured beads together or by drawing squares in a shape and counting the squares to show how the formula was created. The last outcome is to change the way the learners think about Mathematics. The teachers will therefore expect the learners to use their reproduced knowledge to create new knowledge.

Expected use of knowledge

Teachers could expect learners to ultimately use the mathematical knowledge gained in three different ways. Firstly, they can expect the learners to use it within the subject of Mathematics only. They can also expect the learners to use the mathematical knowledge in future mathematical fields like engineering or architecture. The last expected use of mathematical knowledge is to change the way the learners interpret reality. Therefore learners will use mathematical knowledge in everyday life for problem solving.

Responsibility for organising or transforming knowledge

In this belief dimension, the teacher, the learner or both can be responsible for "*organising and transforming the mathematical knowledge*" (Samuelowicz & Bain, 2001, p. 310).

Nature of knowledge

In Mathematics, knowledge can be constructed externally or personalised. If the knowledge is constructed externally, it means that the teacher transferred the knowledge to the learner. If the knowledge is personalised, the teacher merely guides the learner to discover the knowledge by himself/herself.

Learners' existing conceptions

Learners' conceptions of Mathematics can influence the way in which they learn Mathematics and therefore a teacher can decide to take these pre-conceptions into account when teaching to prevent common mistakes or they can choose to ignore these pre-conceptions altogether.

Teacher-learners interaction

There are four types of teacher-learner interaction. A teacher can choose one-way communication. This is where the teacher only teaches the Mathematics and no input from the learners is required. The next is two-way interactions. This is where the teacher only probes the learners to maintain their attention. The third type of interaction is two-way to

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ensure understanding. For example a teacher will teach the learners about calculating the area of a rectangle. The teacher will then ask the learners to do a similar problem and report back. This way the teachers can see whether the concept was grasped or not. The last type of interaction is two-way to negotiate the meaning of the mathematical content. A teacher will therefore ask the learners questions and based on the learners' responses the teacher will decide whether or not to re-teach the content or continue with the work.

Control of content

A teacher can choose to be in control of the content or to let the learners control the content. Therefore, a teacher will decide which mathematical topic should be covered after the other, or it can be determined by the learners. When the learners are in control of the content it means that the teacher will change the topic based on what the learners do in class. What they say and do in class will therefore determine the content that has to be covered. An example is when a teacher decides to do Pythagoras but soon realises that the learners struggle with equations and so decides to do equations instead.

Professional development

The eighth dimension revolves around the importance of professional development. A Mathematics teacher can decide to stress the importance of using Mathematics to develop themselves in a professional capacity or not.

Interest motivation

The last dimension is the source of motivation. A teacher can believe that they are the source from which enthusiasm and motivation should originate or they can believe that it is the learners' responsibility to provide the enthusiasm and motivation.

2.2.2 *THE USES OF EDUCATIONAL TECHNOLOGY*

The conceptual framework that was followed to determine the teachers' use of educational technology was established by van Braak, Tondeur and Valcke (2004). As mentioned in the literature review, they stated that teachers' use of educational technology falls within two main categories: class use and supportive use. To determine into which category a teacher belong the framework by van Braak, Tondeur and Valcke (2004) was adapted and a summary of this framework can be found in figure 2.

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As mentioned in the literature review, class use refers to using educational technology in the classroom as an interactive teaching tool and supportive use is when teachers only use the educational technology for administration and preparation purposes.

Supportive use of educational technology

The categories that indicate supportive use according to van Braak, Tondeur and Valcke (2004, p. 410) is as follows:

- When a teacher uses educational technology for administrative purposes such as keeping an agenda and meeting minutes, e-mail, tracking and calculating learners' marks.
- When a teacher use technology to present information in a different way not to promote better understanding, such as a powerpoint presentation to present theoretical mathematical information.
- When teachers use the internet to search for lesson plans, mathematical exercises and educational software.
- When teachers use educational technology to prepare worksheets for the learners.
- When teachers use educational technology for (Co-)constructing a school website
- When teachers use educational technology to track learners' progress.

Class use of educational technology

The categories that indicate class use according to van Braak, Tondeur and Valcke (2004, p. 410) is as follows:

- Promote deeper understanding of Mathematics
- Regular computer-learner interaction
- Use technology interactively in classroom to enhance learning experience
- Encouraging collaborative learning
- Use educational technology for differentiation in the mathematical content
- Encouraging pupils to train their mathematical skills
- Pupils use educational technology to complete their assignments and projects
- Use educational technology to demonstrate certain mathematical problems
- Encouraging pupils to search for information on the Internet

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- Teaching about the possibilities of using computers in a mathematical environment

CLASS USE OF TECHNOLOGY

- Promote deeper understanding of Mathematics
- Regular computer-learner interaction
- Use technology interactively in classroom to enhance learning experience
- Encouraging collaborative learning
- Use educational technology for differentiation in the mathematical content
- Encouraging pupils to train their mathematical skills
- Pupils use educational technology to complete their assignments and projects
- Use educational technology to demonstrate certain mathematical problems
- Encouraging pupils to search for information on the Internet
- Teaching about the possibilities of using computers in a mathematical environment
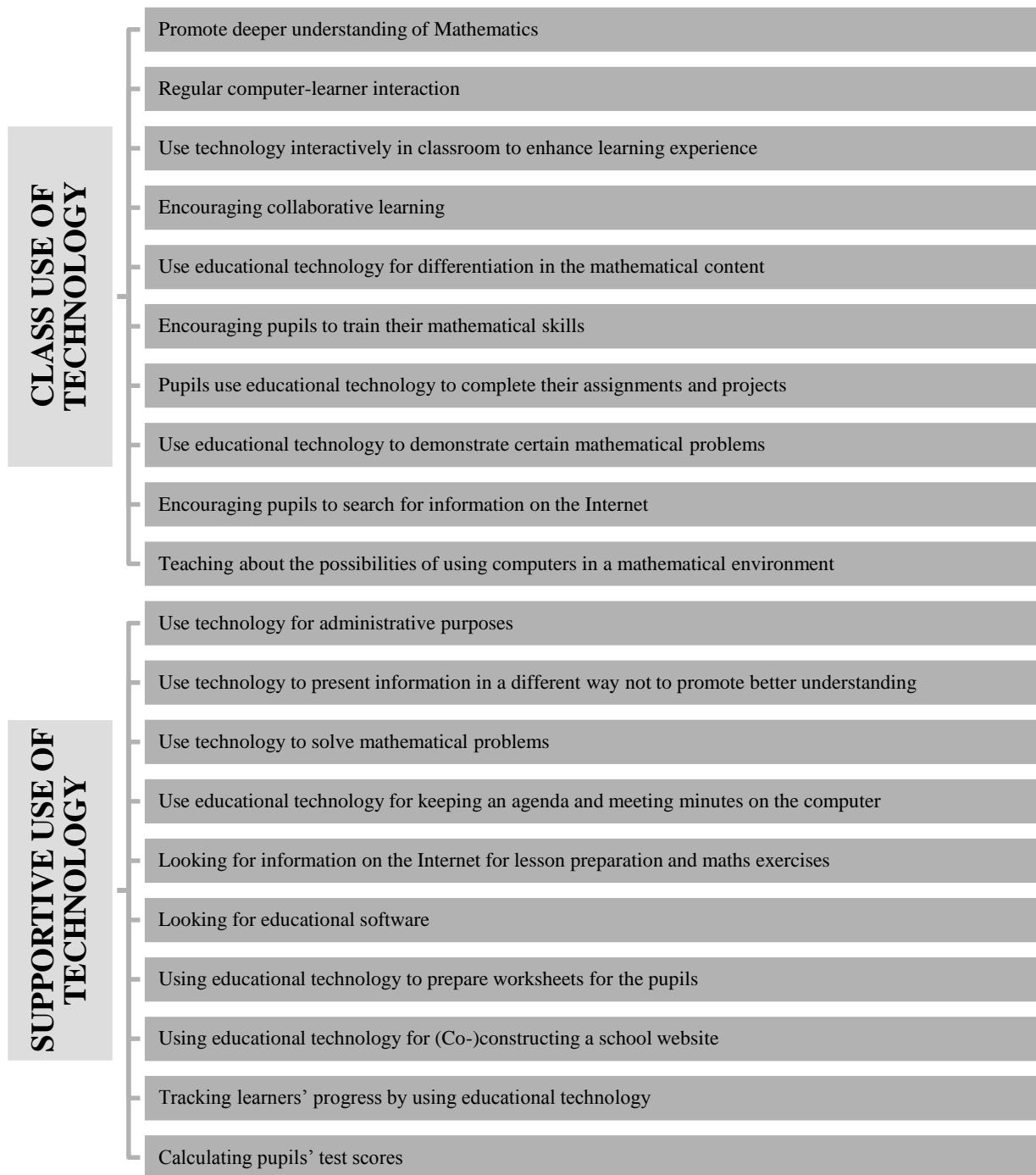
SUPPORTIVE USE OF TECHNOLOGY

- Use technology for administrative purposes
- Use technology to present information in a different way not to promote better understanding
- Use technology to solve mathematical problems
- Use educational technology for keeping an agenda and meeting minutes on the computer
- Looking for information on the Internet for lesson preparation and maths exercises
- Looking for educational software
- Using educational technology to prepare worksheets for the pupils
- Using educational technology for (Co-)constructing a school website
- Tracking learners' progress by using educational technology
- Calculating pupils' test scores

Figure 2: A summary of the difference between class- and supportive use of technology (adapted from van Braak, Tondeur & Valcke (2004).

2.3 CONCLUSION

As per the literature review, many studies exist with regards to the integration of educational technology and pedagogical beliefs. However, very few studies investigated the nature of the relationship between pedagogical beliefs and the use of educational technology.

As explained in the conceptual framework, Samuelowicz and Bain (2001) stated that there are two main belief orientations namely teaching-centred beliefs and learning-centred beliefs. These orientations ranged from completely teaching-centred beliefs, teaching-centred that focuses on learning, learning-centred that focuses on teaching to completely learning-centred beliefs. Within these belief orientations, there are nine belief dimensions namely: desired learning outcomes, expected use of knowledge, responsibility for organising or transforming knowledge, nature of knowledge, learners' existing conceptions, teacher-learners interaction, control of content, professional development, interest motivation.Van Braak, Tondeur and Valcke (2004) stated that a teacher will either use educational technology within the class use category or within the supportive use category. If teachers used educational technology in the class use category, they used it as an interactive tool to help learner's gain better understanding of the subject knowledge. If teachers used educational technology in the supportive use category, they used at only for preparation and administration purposes.

This study investigated the nature of the relationship between teachers' pedagogical beliefs and their use of educational technology in the Mathematics classroom because teachers that use educational technology use it because it already fits within their own beliefs system. It is therefore crucial to explore whether certain beliefs support a specific type of technology use. To explore this relationship the two frameworks chosen to underpin the study was not merged into one framework as the relationship between pedagogical beliefs and technology use has not been clearly defined yet. The frameworks was therefore worked with separately and the conclusions drawn, through the use of both frameworks, was merged as an entity.

CHAPTER 3

RESEARCH METHODOLOGY

3.1   INTRODUCTION

This study was qualitative in nature and a multiple case study research design was followed. Investigating each teacher as an individual case was the most efficient way to gain a better understanding about the nature of the relationship between secondary school Mathematics teachers' pedagogical beliefs and their use of educational technology in the classroom.

Two data collection techniques were used, namely semi-structured interviews followed by non-participatory classroom observations. Each participant was interviewed once and was observed during one lesson. The data was analysed using priori codes for both the observations and interviews. There were a total of 7 Mathematics teachers who took part in the study. The table below illustrates a summary of the activities in answering the two secondary research questions.

Table 1: Summary of activities to answer the secondary research questions

QUESTION 1: What are the secondary school Mathematics teachers' pedagogical beliefs?				
DATA SOURCE	**COLLECTION STRATEGY AND ACTIVITIES**	**VENUE**	**DURATION**	**INSTRUMENT VALIDATION**
7 Secondary School Mathematics teachers	Semi-structured interviews that were audio-taped	The interviews took place at a time that fit both the participants and the researcher.	Approx. 15 minutes	Validated in previous studies by van Braak, Tondeur & Valcke (2004) Recordings and transcriptions
QUESTION 2: How are teachers currently using educational technology in their teaching practice?				
DATA SOURCE	**COLLECTION STRATEGY AND ACTIVITIES**	**VENUE**	**DURATION**	**INSTRUMENT VALIDATION**
7 Secondary School Mathematics teachers	Semi-structured interviews that were audio-taped Non-participatory classroom observations that were noted, not audio-taped	In the mathematics teacher's classroom.	1 period 40 minutes	Notes made according to observation protocol

3.2   RESEARCH PARADIGM

The qualitative nature of the research is what guided the constructivism paradigm. As the study focused on teachers' pedagogical beliefs, the aim was to understand their beliefs and observe the way in which they used technology. The main focus of this paradigm was to interpret a situation as it occurred in the natural environment, and not to interfere or attempt to control the situation. The purpose of this study was not to generalise a phenomenon to a population but rather to interpret the phenomenon itself (Farzanfar, 2005). The premise was therefore that each teacher's beliefs would be different and that they would be influenced accordingly.

Alongside the constructivism paradigm, a constructivist ontological assumption was adopted. This ontological assumption supported the idea that people constructed their own realities (Fekede, 2010). The researcher believes that the above-mentioned beliefs were externally constructed and, therefore, followed a constructivist ontological assumption.

3.3   RESEARCH DESIGN

A qualitative case study was chosen as it "investigates a contemporary phenomenon within its real-life context and addresses a situation in which the boundaries between phenomenon and context are not clearly evident." (Yin, 1993, p. 53). This was the most fitting research design as the teachers were observed in their classrooms natural setting. The teachers were also interviewed to explore their pedagogical beliefs with regards to teaching Mathematics. This is similar to Lim and Chai's (2008) study in Singapore, where 6 teachers were considered the 'cases' of the study. They too interviewed the teachers and observed one "computer-mediated lesson" (Lim & Chai, 2008, p. 811). Similar to Lim and Chai's (2008) study, this study has 7 Mathematics teachers instead of 6 and they too were the cases for this study. Each teacher in this study was treated as an individual case, where after a cross-case an analysis was done.

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3.3.1 SAMPLE AND PARTICIPANTS

For the purpose of this study, stratified purposive sampling was used. The sample was purposely chosen, as the study required research where the school had educational technology readily available and the teachers were adequately trained to use those educational technologies. Therefore, an independent school in Gauteng was chosen for this study. This school was well-equipped with educational technology. There was a total of 8 Mathematics teachers in the secondary school and 7 chose to partake in the study. The teachers consisted of young and old teachers, experienced and non-experienced and male and female. The diversity in the group of teachers was also a big motivation to have chosen that specific school. The school was also chosen for convenience purposes as it was located close to the researcher's home.

3.3.2 DATA COLLECTION

Two data collection techniques were used, namely semi-structured interviews followed by non-participatory classroom observations. Each participant was interviewed once and was observed during one lesson.

3.3.2.1 INTERVIEWS

Semi-structured interviews were used as one of the data collection methods. The 7 Mathematics teachers were interviewed individually. This technique was used to determine the teacher's pedagogical beliefs. The interviews took place at a time that was convenient for both the researcher and the participant. All the interviews took place in the teachers' classrooms except for one, whose interview took place in the school boardroom. The interviews lasted approximately 15 minutes each. The interviews were tape-recorded and transcriptions were made from these recording.

The interview schedule (see Appendix 4) was structured in three sections. The first section was to determine demographic information about the participant. The second section was to determine the teacher's pedagogical beliefs and to determine the teacher's pedagogical beliefs the questions were structured according to the nine belief dimensions. The last section was to determine what educational technology is currently being used.

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3.3.2.2   CLASSROOM OBSERVATIONS

It was important to observe teachers in their natural teaching environment in order to identify how they are using educational technology in their teaching. Therefore, a structured classroom observation protocol (see Appendix 5) was developed in order to record how the teacher uses the educational technologies available in their classrooms. The observation protocol made specific reference to using educational technology for supportive use and class use. The researcher remained an objective observer, and did not intervene during the lesson. The observations were made in the secondary school Mathematics teachers' classrooms. The learners were present in the class, and therefore, their parents were informed of the study and that their child would not be participating in the study.

3.3.3   DATA ANALYSIS

3.3.3.1   INSTRUMENT TO ANALYSE INTERVIEWS

The instrument that was used to analyse the interviews was based on a framework developed by Samuelowicz and Bain (2001).

Belief orientations

Samuelowicz and Bain (2001) developed a framework to describe the dimensions and categories that encapsulates teachers' beliefs about teaching and learning. They set out four types of belief orientations ranging from teaching-centred beliefs to learning-centred beliefs.

They coded the beliefs as follows:

- A: completely teaching-centred belief
- A/b: teaching-centred but the teacher also focuses on learning
- B/a: learning-centred but the teacher also focuses on teaching
- B: completely learning-centred belief

A summary of the belief orientations' codes can be found in table 2. A more detailed explanation of the coding will follow in section 3.4.3.3.

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3.4.3.2 INSTRUMENT TO ANALYSE TECHNOLOGY USE

Van Braak, Tondeur and Valcke's (2004) framework was used to record and categorise teachers' technology use in the classroom. According to this framework a teacher will therefore fall within either the class use category or the supportive use category.

Pre-set questions were posed to the teachers. The questions were in no specific order, but each question was embedded in one of the technology use categories. The following questions were all embedded in the class use category:

- Do you use educational technology to encourage collaborative learning?
- Do you use educational technology for differentiation in the mathematical content?
- Do you use educational technology to encourage learners to train their mathematical skills?
- Do learners use educational technology for the completion of their assignments and projects?
- Do you use educational technology to demonstrate certain mathematical problems?
- Do you use educational technology as an interactive tool for instruction?
- Do you use educational technology to encourage pupils to search for information on the internet?
- Do you use educational technology to teach about the possibilities of using

Contrary to the previous questions, the following questions were all embedded in the supportive use category:

- Do you use educational technology for keeping an agenda and meeting minutes on the computer?
- Do you use educational technology for administration, such as letters and reports?
- Do you use educational technology for e-mail for your job?
- Do you use educational technology to look for information on the internet for lesson preparation and Mathematics exercises?
- Do you use educational technology to look for educational software?
- Do you use educational technology for the preparation of worksheets for the learners?
- Do you use educational technology for the (co)-constructing of the school website?

- Do you use educational technology to track learners' progress?
- Do you use educational technology to calculate learners' test scores?

If a teacher would then answer 'yes' to a supportive use question it would be coded as an 'S', and if they were to answer 'no' to a supportive use question it would be coded with a 'C'. The same was true for the opposite. If a teacher would answer 'yes' to a class use question it would be coded as an 'C', and if they were to answer 'no' to a class use question it would be coded with a 'S'.

A more detailed explanation on the coding can be found in section 3.4.3.3.

3.4.3.3   INTERVIEWS

The interview schedule (see Appendix 4) was structured in three sections. The first section was to determine the teachers' demographical information. The information was not coded or analysed; it was merely reported in the findings. For the second section, the teachers' pedagogical beliefs had to be recorded and categorised. Therefore, priori coding was used to analyse the interviews in the second section. The codes were predetermined and based on the nine belief dimensions and four belief orientations set out by the framework developed by Samuelowicz and Bain (2001). Each question in the in the second section of the interview was based on a belief dimension and therefore the teacher's answer would categorise them within one of the four belief orientations. To code the teachers' answers, the following coding was used. The first letter of the code would establish whether it is a teaching- or learning-centred belief orientation. The second letter represents the belief dimension and the number represents the level of dimension within the belief orientation. The different codes are shown in the table 2.

After the coding took place, each teacher's answers were then tallied according to the amount of A's and B's in order to establish which belief orientation was more dominant and to determine the measure of dominance.

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Table 2: Priori codes used to determine teachers' pedagogical beliefs

Dimensions	Teaching-centred orientations			Learning-centred orientations			
	Imparting information	*Transmitting structured knowledge*	*Providing and facilitating understanding*	*Helping learners develop expertise*	*Preventing misunderstandings*	*Negotiating understanding*	*Encouraging knowledge creation*
Desired learning outcomes	Recall of atomised information	Reproductive understanding	Reproductive understanding	Change in ways of thinking	Change in ways of thinking	Change in ways of thinking	Change in ways of thinking
	TD 1 - A	TD 2 - A/b	TD 3 - A/b	LD 1 - B	LD 2 - B	LD 3 - B	LD 4 - B
Expected use of knowledge	Within subject	Within subject for future use	Within subject for future use	Interpretation of reality	Interpretation of reality	Interpretation of reality	Interpretation of reality
	TE 1 - A	TE 2 - A/b	TE 3 - A/b	LE 1 - B	LE 2 - B	LE 3 - B	LE 4 - B
Responsibility for organising or transforming knowledge	Teacher	Teacher	Teacher shows how knowledge can be used	Learners and teacher	Learners	Learners	Learners
	TR 1 - A	TR 2 - A	TR 3 - A/b	LR 1 - B/a	LR 2 - B	LR 3 - B	LR 4 - B
Nature of knowledge	Externally constructed	Externally constructed	Externally constructed	Personalised	Personalised	Personalised	Personalised
	TN 1 - A	TN 2 - A	TN 3 - A	LN 1 - B	LN 2 - B	LN 3 - B	LN 4 - B
Learners' existing conceptions	Not taken into account	Not taken into account	Not taken into account	Not taken into account	Used to prevent common mistakes	Used as basis for conceptual change	Used as basis for conceptual change
	TL 1 - A	TL 2 - A	TL 3 - A	LL 1 - A	LL 2 - B/a	LL3 - B	LL 4 - B
Teacher-learners interaction	One-way: Teacher to learners	Two-way to maintain learners' attention	Two-way to ensure/clarify understanding	Two-way to negotiate meaning	Two-way to negotiate meaning	Two-way to negotiate meaning	Two-way to negotiate meaning
	TT 1 - A	TT 2 - A/b	TT 3 - B/a	LT 1 - B	LT 2 - B	LT 3 - B	LT 4 - B
Control of content	Teacher	Teacher	Teacher	Teacher	Teacher	Teacher	Learners
	TC 1 - A	TC 2 - A	TC 3 - A	LC 1 - A	LC 2 - A	LC 3 – A	LC 4 - B
Professional development	Not stressed	Not stressed	Not stressed	Stressed	Stressed	Stressed	Stressed
	TP 1 - A	TP 2 - A	TP 3 - A	LP 1 - B	LP 2 - B	LP 3 - B	LP 4 - B
Interest and motivation	Teacher's	Teacher's	Teacher's	Learners'	Learners'	Learners'	Learners'
	TI 1 - A	TI 2 - A	TI 3 - A	LI 1 - B	LI 2 - B	LI 3 - B	LI 4 - B

The third section of the interview was also analysed according to priori codes. Each question was developed to classify a teacher use of a specific technology as either *class use* or *supportive use*. If a teacher's had a supportive use answer, it would be coded with an "S" and if the teacher had a class use answer, it would be coded with a "C". Table 3 shows the coding for each item.

Table 3: Priori codes to determine teachers' use of educational technology.

Item nr	Use of educational technology	Code
16	Keeping an agenda and meeting minutes on the computer Om 'n agenda en notules van vergaderings te hou op die rekenaar	S
17	Administration, such as letters and reports Administrasie, soos briewe en verslae	S
18	Encouraging collaborative learning Aanmoediging van samewerkende leer	C
19	E-mail for your job E-pos vir jou werk	S
20	Differentiation in the mathematical content Differensiasie in wiskundige inhoud	C
21	Looking for information on the Internet for lesson preparation and maths exercises Die soek van informasie op die internet vir les voorbereiding en wiskunde oefeninge	S
22	Encouraging pupils to train their mathematical skills Om leerders aan te moedig om hul wiskunde vaardighede te oefen	C
23	Looking for educational software like GeoGebra Om opvoedkundige sagteware soos GeoGebra te soek	S
24	Learners' completion of their assignments and projects Voltooing van leerders se take en projekte	C
25	Demonstrating certain mathematical problems Demonstrering van sekere wiskundige probleme	C
26	Preparing worksheets for the pupils Opstelling van werkkaarte vir leerders	S
27	(Co-)constructing a school website Die mede-bou van die skool webblad	S
28	As an interactive tool for instruction As 'n interaktiewe instrument vir instruksie	C
29	Tracking learners' progress Leerders se vordering dop te hou	C
30	Encourage learners to search for information on the Internet Om leerder te motiveer om informasie te soek op die internet	S
31	Calculating pupils' test scores Om leerders se punte te bereken	S
32	Teaching about the possibilities of using computers in a mathematical environment Die leer van moontlike gebruike van tegnolgie in 'n wiskundige omgewing	C

3.4.3.4 OBSERVATIONS

The classroom observations were carried out on a day fitting both the teacher and the researcher. The observation protocol (Appendix 5) provided a list of pre-set aspects that had to be examined during the lesson. These aspects included the following: what educational technology was available for the teachers' use, whether or not they used the technology and if they used the technology, what it was used for. Additional comments could also be noted on the observation protocol if something occurred in the class that the researcher deemed applicable to the study.

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3.5   METHODOLOGICAL NORMS

3.5.1 TRUSTWORTHINESS

To ensure the trustworthiness of the data, various strategies were employed. The first strategy was to make use of multiple data sources. The participants were interviewed and observed and, thus, the data obtained from one participant could be crystalised and verified. Credibility was also ensured by means of stakeholder checks. The participants were asked to verify the raw data from the interviews. The participants were sent the transcripts in order to verify that the transcripts were made thoroughly and accurately. After the completion of the data analysis, the participants were asked to comment on the conclusions and to confirm whether the findings were in line with their personal experiences.

The third strategy employed was intra- and inter coder reliability. Another coder was asked to code the data in order to ensure that there was consistency in the coding of the data. This peer examination is also a strategy to control against bias.

The last strategy used to ensure trustworthiness was the keeping of a research journal. By keeping a research journal, all the steps during research were documented. This documentation kept track of all the decisions made, conclusions drawn and how the researcher arrived at the conclusions.

3.5.2 ETHICAL CARE AND CLEARANCE

The nature of this study was not experimental or intrusive and did not require teachers to divulge personal information. The questioning in the interview was of a professional nature and, during the classroom observation, no interruptions were made. Ethical clearance was obtained in compliance with the rules and regulations of the University of Pretoria before research commenced. This application included the following:

Voluntary participation

Teachers were informed that participation in the study was completely voluntary and that they could withdraw at any time by means of a letter. This letter was signed by each participant who agreed to be part of the study. This meant that there was no captive audience in the study and no incentives were given to the participants.

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Informed consent

As mentioned above, each teacher received a letter, which they signed as proof of their consent to participate in the study. Apart from the consent sought from the teachers, consent was also sought from the principal. The principal also received a letter which he signed as proof of consent. No consent was sought from the parents of the learners as they were not participants in the study. They did, however, receive a letter informing them of the presence of the researcher in the class.

The teachers who participated in the study were all fluent in English although all were Afrikaans first language speakers and, hence, there were no difficulties resulting from consent forms being issued in English.

Safety in participation

It was unlikely that the participants would be harmed during the duration of the study. Teachers might have felt uncomfortable knowing that the principal would find out details regarding their use of educational technology in the classroom. This issue was addressed by assuring the participants that pseudonyms would be used so that, even though the principal might read the report, he would not be able to tell which data was obtained from which teacher.

Privacy, confidentiality and anonymity

The participants were informed that their identities would be kept completely anonymous and confidential, as only the researcher would know the true identity of the participants and pseudonyms would be used in the final dissertation, which would prevent their identities from becoming apparent.

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CHAPTER 4: DATA ANALYSIS

4.1   INTRODUCTION

The data analysis took place by individually analysing each of the 7 teachers' cases. Their interview data was triangulated with the classroom observation to ensure credibility of the data. The purpose of the interview was to determine and classify what teachers' pedagogical beliefs are as well as establishing their presumed beliefs on their technology usage in the classroom. The observation was then used to compare their espoused use of educational technology to the observed data.

Each of the 7 teachers' cases will be discussed separately. In each case the demographical information, pedagogical beliefs and technology use as ascertained in the interview and observation, will be discussed. Thereafter, a cross case analysis will be discussed and a summary of the conclusions will be made. A summary of the conclusions can also be found in table 6 and table 7.

4.2   CASE ANALYSIS

4.2.1 CASE 1: ANNA

Demographical information: Anna is a young teacher at the school with eight years' experience teaching Mathematics. She is currently teaching the junior learners at the school. She has a Bachelor's degree and holds the position of teacher at the school.

Educational technology available in the class: The classroom was equipped with a desktop computer, overhead projector, data projector and white board in the front of the class.

The observed lesson

Upon entering the class, the learners politely stood up to greet the researcher and Anna informed them that the researcher would observe the lesson for the period. When Anna started the lesson the topic discussed was the straight-line function.

Technology use: Anna only made use of the overhead projector and whiteboard in this lesson. The problems the learners had for homework were imprinted on a transparency and

the problems were solved as she wrote the answers on the transparency. The learners did not interact with the technology and the interaction between Anna and the learners was mainly one-way. If the learners did not understand something they asked a question and Anna replied by explaining the problem on the whiteboard. There was no interaction with the technology in the class and the learners were not allowed to use calculators.

The interview

Technology use: When Anna was asked in her interview if she could give a ratio of who speaks the most in class she said that she speaks 60% of the time and the learners speak 40% of the time. She also stated in her interview that she does use the educational technology interactively. From the interview it was very clear that she does use the technology but mainly for preparing tests, keeping test scores and e-mail. She was not confident with using educational technology to encourage interactive involvement with the technology in class.

Pedagogical beliefs: From the first question Anna answered as a teaching-centred teacher. When asked what the desired outcomes are she stated that she gives the learners enough examples to make sure they can recall the information when they are in a test. She continued with a teaching-centred answer when asked how she thinks the learners would apply their knowledge one day, by saying:

> *'wel in my opinie is dit dat op skool leer ons hulle basiese goed wat hulle moet kan verstaan wat die basis vorm van jou ingineurswese en jou argitektuur en daai goed'*

> *'well, in my opinion, at school we teach them the basics that they need to understand and this forms the base for engineering and architecture and that stuff'*

She continues with the same question and gives a learning-centred answer by saying:

> *'en dan jou basiese om gaan in die lewe umm… ek dink sommer aan finansies as 'n afdeling waar jy moet wys hoe rente bereken is, hoe persentasies werk want persentasies gebruik jy baie'*

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> *'and the basics to live umm… I think of the financessection where you have*
> *to show how interest was calculated, how percentages work because you use*
> *percentages a lot'*

Anna was very clear in her interview that she was in charge of the lessons and that the learners do not help in the organising and construction of the content. However, if she notices that the learners do not keep up with her planning, she will return to that content to make sure they understand. As before, Anna started with a teaching-centred answer and then reverted to a learning-centred answer.

Discussion

Some discrepancies were presented between Anna's interview and classroom observation. Her ratio of teacher- to learner talk in class was 60:40 but during the lesson she spoke approximately 90% of the time. She also mentioned that she uses the educational technology interactively but this was not observed in the lesson. According to Van Braak, Tondeur and Valcke (2004), Anna will be classified as a teacher that uses educational technology mainly for supportive use and rarely uses educational technology for class use purposes and according to the framework of Samuelowicz and Bain (2001), Anna has teaching-centred beliefs that sometimes focus on learning. There seems to be a relationship between Anna's beliefs and technology use.

4.2.2   CASE 2: BELINDA

Demographical information: Belinda is a thirty eight year old with five years of teaching experience. She also has a Bachelor's degree and her position at the school is a teacher.

Technology available in the class: Belinda was also equipped with a personal computer, data projector, overhead projector and white board.

The observed lesson

Upon entering Belinda's class she was busy explaining algebraic expressions.

Technology use: For the duration of the lesson, Belinda made use only of the whiteboard. The learners therefore did not interact with any educational technology during the lesson. They were also not allowed to use calculators. Interaction between her and the learners

were however very much two-way. She constantly asked the learners questions that they would then have to answer.

The interview

Technology use: Belinda clearly stated that she uses educational technology interactively in the class. She also mentioned that she uses technology very much for administration and preparation purposes.

Pedagogical beliefs: During the interview with Belinda, it was apparent from early on, that her approach to the answers were very much teaching-centred as she used vocabulary like "I" and "me" a great deal. She believes strongly that the learners are not capable of organising and transforming mathematical content or knowledge. She stated clearly that her planning should be followed strictly in order to cover the content pre-scribed by the curriculum. Contrary to the other teaching-centred beliefs she expressed the following about the expected use of mathematical knowledge one day:

> *'I do understand that they won't necessarily use the exact sums and solve these sums but it is a problem solving ability and the ability to look at a problem and figure out what they need to do in order to solve that problem which is a very important life skill whether he is directly working with mathematics or anything else like in a managing role or working as a plumber even.'*

Discussion

Belinda's interview did not correlate with her classroom observation at all. She mentioned that she uses educational technology interactively in her lessons and that she encourages learners to use educational technology but it was apparent during the classroom observation that, that was not the case. During the observation Belinda made no use of any of the educational technology that was present in the class. The conclusion that could be drawn, is that Belinda mainly used educational technology for supportive use as there was no evidence in the classroom observation that she used any educational technology at all.

After analysing the transcripts of the interview it became clear that Belinda has teaching-centred beliefs. Belinda only had one learning-centred response and that was toward the application of the learners' knowledge one day.

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4.2.3 CASE 3: CHRISTINE

Demographical information: Christine has nineteen years' experience in teaching Mathematics. She is currently the head of department at the school where she teaches. She teaches the senior learners at the school.

Technology available in the class: In Christine's class there is a personal computer, data projector, white board and a writing tablet computer. The computer was loaded with graphical software called "Autograph".

The observed lesson

Upon entering Christine's class there was a calmness emanating from the learners. She was busy with log-functions. The log graphs were being projected while she was explaining on the white board. The graphs were drawn on mathematical software called "Autograph". Christine used these graphs to present the learners with different problems that they had to solve by using both the graphs and their mathematical skills. By having the two accurate graphs next to one another the learners could come to accurate conclusions rather than guessing.

Technology use: Christine engaged the learners with the educational technology. A learner asked if he can use his calculator and Christine did not discourage the use of the calculator, she did however mention that they should take caution to make sure they do not make a mistake while typing.

The interview

Technology use: In her interview, Christine stated that she tries to encourage the learners as far as possible to use technology and search for information on the internet as well as completing their assignments with the use of educational technology, but she admits that she can improve on her approach to improve their use of educational technology use.

> *'so ek sal sê op hierdie stadium doen ek dit nie so baie soos ek dit graag wil doen nie, so dit sal nog bietjie verander.'*

> *'so I won't say that I am currently using it as much as I would like to, so I will still change it a bit'*

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Pedagogical beliefs: In Christine's interview it became clear that she puts focus on the learner. She adapts her approach to make sure that all the learners get equal amounts of attention and that all of the learner levels are covered in her teaching. She also mentioned that she has to plan properly but ultimately the learner determines what is taught in class as she cannot teach something if she knows there is another topic that needs more attention at that specific time. Christine gave a very learning-centred answer when she talked about the interaction between the teacher and the learners:

> *'Kyk ek dink dit is belangrik vir my dat mens voordurend terugvoer moet kry van die kinders ummm… so ek hou daarvan om vir kinders vrae te stel voordat ek vir hulle 'n antwoord gee wil ek graag die kinders se insette ook hê. Want as dit net die onderwyser is wat die dinkwerk doen dan kan jy, ek sê altyd, parasiete hê in die klas wat beteken hulle doen niks nie en hulle kry net by jou alles. So dit is defnitief 'n twee rigting kommunikasie, so ek sal sê vir my gaan dit 50 50 solank dit nie net een kind is wat betrokke is die heeltyd nie jy moet eintlik verskillende tipe kinders en die level van kinders se prestasie kan betrek by die les. So ek sal byvoorbeeld 'n maklike vraag vrae vir 'n kind wat sukkel en ook vir hom sê jy kan maar 'n vragie vra of jy kan maar af… sonder dat ek jou in 'n posisie gaan plaas waar ek jou afbreek.'*

> *'I think it is important to get constant feedback from the learners ummm… so I like to pose questions to the learners and to get their input before I give them the answers. Because if it is only the teacher doing the thinking then you can, like I always say, have parasites in your class which means they do nothing and get everything from you. So it is definitely two way communication, so I will say 50 50 as long as it is a variety of kids answering and not just one kid all the time, you have to ask different kids and different levels of questions so you can involve all the learners in the lesson. So for instance, an easier question will involve the kids that struggle a bit more and you say that they can ask a question and… without putting them in a position where you are breaking the child down.'*

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Discussion

Christine's classroom observation correlated completely with her interview. In this case, it is clear that Christine - who has learning-centred beliefs and focuses on teaching - uses her educational technology for both supportive use and class use equally.

4.2.4   CASE 4: DEBRA

Demographical information: Debra is thirty five years old and has 12 years of teaching experience. She has an Honours degree and teaches Mathematics to the senior learners at the school.

Technology available in the class: In Debra's class there was a personal computer, data projector and the pen tablet that she was using.

The observed lesson

Upon arrival in her class, it was clear that she was quite comfortable with using educational technology as she was busy writing on a pen tablet, which was projected on the wall. Debra was busy marking functions homework. The homework answers were typed and projected on the screen and as she explained she drew graphs on a blank page also using Microsoft Office Word. Debra was not using the educational technology, which she is clearly comfortable with, as an interactive tool. She was using it as if it was an overhead projector, just presenting the information. By presenting the information this way is saves time because she could easily access a blank page, if the learners had difficulty seeing, it is easy for her to enlarge the image and the content in their books can be projected easily without having to go through the process of burning transparencies.

Technology use: A learner in her class asked about the use of a calculator and Debra answered that if a question asked to show calculations it would be better not to make use of a calculator.

The interview

Technology use: When interviewed, Debra was very confident on the question regarding using educational technology for class use purposes.

Pedagogical beliefs: All Debra's answers to my questions were teaching orientated. She focussed all her answers around what she can do to help the learners and not around what the learners can do to improve their learning. Debra believes that the Mathematics will help the learners in a mathematical field one day, she believes that she is solely responsible for organising and transforming mathematical content and knowledge, and that the learners build their knowledge from the external knowledge she provides them. When asked who speaks most in the class her first reaction was:

'Die onderwyser, ek praat die heeltyd.'

'The teacher, I speak the whole time.'

Discussion

There was a conflict between how Debra uses her educational technology and how she thinks she uses her educational technology. There were no signs in the classroom observation that she makes use of educational technology for class use purposes but rather only use it for supportive use. In conclusion, she too holds teaching-centred beliefs regarding the teaching of Mathematics.

4.2.5 CASE 5: EDWARD

Demographical information: Edward is a grade head at the school and has 15 years of teaching Mathematics. He also teaches the senior learners at the school.

Technology available in the class: He too had a personal computer, data projector and white board.

The observed lesson

Edward was busy teaching logarithms when the lesson was observed.

Technology use: Edward had a different approach to using his educational technology. His data projector shone on his whiteboard. He had his PowerPoint presentation with all the sums typed out. As he explained he would let one step at a time present itself on the board and then he will move on to the next step, etc. The learners constantly gave alternate answers and then he would write the answers in the open space left on the board. If the

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learners did not understand something he could just write on top of the presentation with his whiteboard marker. Edward did not mind if the learners used calculators, but the topic was logarithms and teachers are generally not opposed to the use of a calculator. He definitely made use of his educational technology but he too only used it as an instrument for presentation and not as an interactive tool.

The interview

Technology use: When asked in the interview if he uses the educational technology as an interactive tool he replied in the affirmative.

Pedagogical beliefs: Discovering Edward's beliefs were much more difficult as he came across as very concerned for the learners, yet the root of his answers stemmed from teaching-centred beliefs. Edward believes that he takes all the responsibility for the organisation and transformation of the mathematical content and knowledge. When asked how the learners will apply their mathematical knowledge one day he said the following:

> *'Wel hopelik gaan swot die leerders eendag in 'n wiskundige rigting, van hulle. En hopelik sal van hulle ingeneurs word waar die trigonometrie en ander aspekte baie vir hulle sal beteken of argitekte. So mens hoop dat die beroep wat hulle eendag doen, dat wiskunde 'n rol sal speel.'*

> *'Well, hopefully the learners will go study in a mathematical field, some of them. And hopefully some of them will be engineers where they will make use of trigonometry or other aspects or architects. So you hope that Mathematics will play a role in their occupation one day.'*

When asked about the teacher and learner interaction he confirmed the teaching belief that had some aspects of learning-centeredness. He stated the following:

> *'Ek verkies vraag en antwoord. So ek verkies dat die leerders aktief deelneem in die klas eerder as wat ek net onderrig en hulle net na my luister, so ek verkies aktiewe deelname en hierdeur probeer ek spesifiek aandag skenk aan almal en ek wil almal betrek per les sodat mens kan agter kom waar daar leemtes is of waar hul nie verstaan nie.'*

> *'I prefer question and answer. So I prefer that learners take part actively in class rather than me teaching and them just listening, so I prefer active*

> *participation and through this technique I try to pay specific attention to involve everyone in the lesson so you can see where the learners don't understand.'*

Discussion

Having observed the lesson and interviewing Edward the conclusion was that he has strong teaching-centred beliefs that rarely focuses on learning. He also only uses the educational technology for supportive use although he stated otherwise.

4.2.6   CASE 6: FRANCIS

Demographical information: Francis is forty one years old and started teaching in 1996. Currently she teaches senior mathematics learners at the school. Francis is also a Grade Head at the school.

Technology available in the class: In her class she is equipped with a personal computer, data projector, overhead projector and whiteboard.

The observed lesson

Upon entering her class she was using the overhead projector. The learners were marking their homework on exponential equations. The transparency had the homework already written out so the learners were just marking their own work and doing corrections.

Technology use: During this lesson Francis only made use of the overhead projector and the whiteboard. She would explain some sums on the overhead projector and when learners had questions she would revert to using the whiteboard. Francis mentioned during the lesson that if the questions state that you may not use a calculator, then the learners should show all their steps. She did not indicate whether she was in favour of them checking their answers with the calculator. Throughout the lesson there was not a lot of interaction between the learners and the teacher or the learners and the educational technology. Francis mainly explained the work as the learners listened and answered questions when she was asked. Interactive use of the educational technology was not observed during the lesson.

The interview

Technology use: When interviewed, Francis' conception of how she uses educational technology differs from what was observed in the class. She stated that she uses educational technology for all the supportive use reasons but she also stated that she uses educational technology to encourage co-operative learning. She also stated that she uses educational technology as an interactive tool for instruction.

Pedagogical beliefs: In the interview with Francis her main concern was with the learners. Her answers were mainly focussed on "guiding the learners" with regards to studying and future use of mathematics. When asked how the learners will use their knowledge one day she said:

> *'I think generally if they don't go study in a mathematical direction maths is just a guidance about how to think, how to plan, it's abstract thinking, it's problem solving, you don't necessarily use maths every day, not if you are not going to go in that direction.'*

Francis believes that she is mainly in charge of constructing their knowledge, organising the content and transforming the knowledge. She stated that in her class she thinks she speaks most of the time and then contradicted herself by saying:

> *'ratio wise, I think fifty-fifty, no, I strive for sixty forty ratio, me being sixty them being forty.'*

Discussion

In her interview she expressed feelings of learning-centred beliefs but in some questions her answers reflected more of a teaching-centred belief system. Francis does not make use of a great deal of her educational technology and when she does make use of it, she mainly uses it for supportive uses. Francis also has teaching-centred beliefs but she does focus on learning in some aspects.

4.2.7 CASE 7: GERDA

Demographical information: Gerda is a young teacher at the school with eight years of experience. She teaches Mathematics to the juniors and Mathematical Literacy to the seniors.

Technology available in the class: Gerda had a personal computer, white board, data projector and overhead projector visible in the class.

The observed lesson

Gerda was busy with exponents upon entering the class. An exponents' song video was playing through the data projector. The kids did not partake in the song they only watched.

Technology use: As soon as the YouTube video was done Gerda switched over to a PowerPoint presentation. The presentation shone on her whiteboard in front of the class as that way she can write on top of her presentation on the board. The content of the presentation is already given to the learners as notes and therefore the learners do not have to write anything down. This scenario faced me with the question whether Gerda was using the educational technology interactively or not. The conclusion was the following. If she had put the video up and the learners sang and danced with the video, then the video was interactive but, instead, the learners only watched and therefore the information transferred only one way. The same goes for the presentation. Gerda only presented the information by means of using educational technology, but the information transferred was again just one way.

The interview

Technology use: In Gerda's interview, she stated that she did use educational technology as an interactive tool for instruction. She also stated that she uses educational technology for collaborative learning and the teaching and that she teaches the learners to use computers in a mathematical environment.

Pedagogical beliefs: Gerda believes that mathematics is part of everyday life and that is how she teaches it to her learners. She said:

> *'... we are busy with volume at the moment and you can use that in your*
> *everyday life. For example we just started building at our house and we*

built a swimming pool and we tiled and and and and I used all the skills
of perimeter, area and volume to calculate the cost of the building so
therefore for me umm… they do apply the maths I teach them every day
in everyday life.'

She also believes that the learners should speak more in class in order to discuss the content being delivered. On the other hand, she states that she is in charge of the content and that the learners' knowledge is constructed externally.

Discussion

Although Gerda makes use of all the educational technology available to her, she is still using the educational technology for teaching-centred practices and therefore not for class use but rather for supportive use. When it comes to Gerda's pedagogical beliefs she is in between teaching-centred and learning-centred, as her interview responses were almost fifty-fifty.

4.3   CROSS CASE ANALYSIS

In the following section, the cases of each teacher will be compared with one another. Their pedagogical beliefs and use of educational technology will be compared and a summary of the teachers' beliefs and technology will be given. The nature of the relationship between teachers' pedagogical beliefs and their use of educational technology in the classroom will also be discussed.

Demographical information: The teachers that took part in this study were all between the ages of 30 and 43 and their experience levels range between 5 and 19 years. They all have Bachelor's degrees with the exception of Debra, who has an honours degree, and Francis that has her Higher Education Diploma (HED). The demographical information of the teachers can be found in table 4 below.

Table 4: Teachers' demographical information

	Anna	*Belinda*	*Christine*	*Debra*	*Edward*	*Francis*	*Gerda*
Gender	Female	Female	Female	Female	Male	Female	Female
Age	33	38	43	35	43	41	30
Teaching grades	8 and 9	8 and 9	10 and 12	10 and 11	11 and 12	10 and 11	8 and 11
Teaching experience (excluding this year)	8	5	19	12	15	12	8
Highest qualification	Bachelor's degree	Bachelor's degree	Bachelor's degree	Honours degree	Bachelor's degree	Bachelor's degree with an HED	Bachelor's degree
Position at school	Teacher	Teacher	Head of Department	Teacher	Grade Head	Grade Head	Teacher

Technological use: From the observations and interviews it was clear that all the teachers used the personal computer in their class. All seven teachers used the computer for supportive uses such as administration, e-mails, setting tests, notes and examines, and keeping record of learners' marks and progress. Of the seven teachers only Edward and Gerda do not contribute to the co-constructing of the school website. When it came to the teachers' use of the educational technology for class use there was conflicting data. It was consistent between all six cases, with the exception of Christine, that the teachers were either not clear on the meaning of "interactive tool" and "collaborative learning" or they just did not use the educational technology as an interactive tool or for collaborative learning in the specific lesson that was observed. All of the teachers uses the internet to look for different ways of teaching and different examples to ensure differentiation in the mathematical content. Five of the seven teachers let the learners make use of educational technology to complete their assignments and tasks. These teacher would therefore let the learners use calculators, computers or mathematical software to complete assignments at home. Christine stated that she would like to use it more and Anna said she does not do it at all. On the question whether they use the educational technology to encourage the learners to train their mathematical skills, to search for information on the internet and teaching about teaching about the possibilities of using computers in a mathematical environment, there was yet again an inconsistency as to what they think they do and what was observed. A summary of the teachers' view of their use of educational technology can be found in table 5 below.

Table 5: Teachers' view of their use of educational technology.

	Use of educational technology for:	Anna	Belinda	Christine	Debra	Edward	Francis	Gerda
SUPPORTIVE USE	Keeping an agenda and meeting minutes on the computer	Y	Y	Y	Y	Y	Y	Y
	Administration, such as letters and reports	Y	Y	Y	Y	Y	Y	Y
	E-mail for your job	Y	Y	Y	Y	Y	Y	Y
	Looking for information on the Internet for lesson preparation and maths exercises	Y	Y	Y	Y	Y	Y	Y
	Looking for educational software	Y	Y	Y	Y	Y	Y	Y
	Preparing worksheets for the pupils	Y	Y	Y	Y	Y	Y	Y
	(Co-)constructing a school website	N	Y	Y	Y	N	Y	N
	Tracking learners' progress	Y	Y	Y	Y	Y	Y	Y
	Calculating pupils' test scores	Y	Y	Y	Y	Y	Y	Y
CLASS USE	Encouraging collaborative learning	N	Y*	Y*	Y*	Y*	Y*	Y*
	Differentiation in the mathematical content	Y	Y	Y	Y	Y	Y	Y
	Encouraging pupils to train their mathematical skills	N	Y*	Y	Y*	Not enough yet	N	Y*
	Learners'' completion of their assignments and projects	N	Y	Not enough yet	Y	Y	Y	N
	Demonstrating certain mathematical problems	Y	Y	Y	Y	Y	Y	Y
	As an interactive tool for instruction	Y*	Y*	Y	Y*	Y*	Y*	Y*
	Encourage learners to search for information on the Internet	Y*	Y*	Not enough yet	Y*	N	Sometimes	Y*
	Teaching about the possibilities of using computers in a mathematical environment	N	Y*	Y*	Y*	Y*	N	Y*

*Not observed in classroom observation

Pedagogical Beliefs

By making use of the framework developed by Samuelowicz and Bain (2001), each teacher was placed according to their beliefs. Their beliefs were based on their responses in the interview, as their beliefs could not be observed in the lesson. The following information

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was derived from their interviews. All the teachers except Edward and Francis believed that the desired outcomes could be met by giving enough examples that differ from one another. What was deducted from these answers are that the teachers want the learners to be well prepared for tests and examinations and therefore the more examples they give them the wider the range of questions are covered. Edward and Francis, however, were more concerned with guiding the learners to the outcomes with interaction and facilitation. By looking at this aspect alone, one would say that all the teachers except Edward and Francis have teaching-centred beliefs.

But this is not the only aspect that should be considered when attempting to determine pedagogical beliefs. Teachers were also asked how they expected the learners to use their knowledge. If the teachers answered this with regards to their specific subject, it would be indicative of teaching-centred beliefs. All the teachers answered from the perspective of Mathematics or Science, but Belinda, Christine, Francis and Gerda added that it helped to develop problem-solving skills and with "everyday" activities. This indicated that these four teachers had some learning-centred beliefs. The following belief dimension involved the organisation and transformation of knowledge. In this question it was unanimous that all the teachers believed that the teacher was the only person in charge of organising and transforming knowledge. Therefore, with regards to this specific belief dimension all the teachers held teaching-centred beliefs.

The next aspect involved the learners' existing pre-conceptions with regards to Mathematics. Here the answers were split in three. Belinda, Edward and Debra did not take their pre-conceptions into account, Anna, Francis and Gerda used it to prevent mistakes and Christine used their pre-conceptions as a basis for conceptual change. Therefore, Belinda, Edward and Debra held teaching-centred beliefs with regard to this aspect and Christine held learning-centred beliefs. Anna, Francis and Gerda had teaching-centred beliefs that focused somewhat on learning.

When it came to the teacher-learner interaction, all the teachers said that two-way interaction is needed, which led me to believe that all the teachers had some learning-centred beliefs. On the next aspect all the teachers had teaching-centred beliefs as all the teachers believed that only the teacher was in control of the content.

Lastly, the teachers were asked whether the teacher or learner should be more motivated in the classroom. Anna, Belinda and Debra answered both, Christine, Edward and Francis said

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the teacher and Gerda said that the learners should be more motivated. Gerda would then have learning-centred beliefs whereas the rest would have teaching-centred beliefs.

Determining each teacher's pedagogical belief system was therefore a challenge, as all the teachers showed signs of having a little of both belief systems, but after careful analysis the conclusions were as follows:

Anna has teaching-centred beliefs and sometimes focuses on learning.

Belinda has teaching-centred beliefs.

Christine has learning-centred beliefs and sometimes focuses on teaching.

Debra has teaching-centred beliefs.

Edward has teaching-centred beliefs and rarely focuses on learning.

Francis has teaching-centred beliefs and sometimes focuses on learning.

Gerda has teaching- and learning-centred beliefs. Her responses indicated equal beliefs towards both beliefs systems.

A summary of the teachers' pedagogical beliefs can be found below in table 6.

The nature of the relationship between the teachers' pedagogical beliefs and their use of educational technology:

When comparing each case, it seems that in the case of these teachers the pedagogical beliefs do relate to the teachers' use of their educational technology in the way that the more teaching-centred a teacher is, the more they only use educational technology for supportive use. On the other hand, the more learning-centred a teacher is the more they used educational technology for class use.

The following examples demonstrate this relationship. Anna, Edward and Francis have teaching-centred beliefs that sometimes focus on learning and use their educational technology for supportive use. Belinda and Debra also have teaching-centred beliefs but use their educational technology for supportive use only. Gerda has teaching- and learning-centred beliefs and uses all her educational technology for mainly supportive use and

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sometimes for class use. Lastly, Christine has learning-centred beliefs that focus on teaching and she uses her educational technology for supportive and class use.

Table 6: Summary of teachers' pedagogical beliefs

Belief	*Anna*	*Belinda*	*Christine*	*Debra*	*Edward*	*Francis*	*Gerda*
Desired learning outcomes	Achieved with enough examples	Achieved with adequate examples and additional homework examples	Variation in questions and levels to change their way of thinking	Achieved with enough exercises and examples	Active participation to involve all the learners	Guidance to change their way of thinking	Achieved with examples and facilitation
Expected use of knowledge	In the field of mathematics and in finances	Problem solving abilities in any occupation	In subject field and everyday life	In the field of mathematics	In the field of mathematics	In the field of mathematics and in problem solving activities	Interpretation of reality
Responsibility for organising or transforming knowledge	Teacher	Teacher	Teacher	Teacher	Teacher	Teacher	Teacher
Nature of knowledge	Personalised by means of problem solving	Externally constructed	Personalised by means of problem solving	Externally constructed	Personalised to help develop expertise	Externally constructed	Externally constructed
Learners' existing conceptions	Used as basis to prevent mistakes	Not taken into account	Used as a basis for conceptual change	Not taken into account	Not taken into account	Used as basis to prevent mistakes	Used as basis to prevent mistakes
Teacher-learners interaction	Two-way to maintain attention	Two-way to maintain attention but mainly teacher	Two-way to ensure understanding	Two-way to maintain attention but mainly teacher	Two-way to ensure understanding	Two-way to maintain attention	Two-way to negotiate meaning
Control of content	Teacher	Teacher	Teacher but learners have some control	Teacher	Teacher	Teacher but learners have some control	Teacher
Professional development	Stressed	Stressed	Stressed	Stressed	Stressed	Stressed	Stressed
Interest and motivation	Both	Both	Teacher	Both	Teacher	Teacher	Learners

One can therefore state that there is a relationship between teaching-centred beliefs and using educational technology for supportive use but that this is not the only factor that influences technology use. There is also a relationship between learning-centred beliefs and educational technology class use. A continuation on the findings will be discussed in the following chapter.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1   FINDINGS

In this section the findings of this study will be presented in the following order. Firstly, the research questions will be discussed and whether the findings could be used to answer these questions. Thereafter, the findings will be discussed in terms of the current literature available and how this study contributes towards the greater body of knowledge with regards to pedagogical beliefs and the use of educational technology.

5.1.1   THE RESEARCH QUESTIONS

The primary research question for the study was:

What is the nature of the relationship between teachers' pedagogical beliefs and their use of educational technology in the Mathematics classroom?

To answer this question two secondary questions were posed:

1. What are the secondary school Mathematics teachers' pedagogical beliefs?
2. How are teachers currently using educational technology in their teaching practice?

The data collected for each of the secondary questions was discussed in the previous chapter and therefore, the relationship between the teachers' pedagogical beliefs and the use of educational technology. Therefore, the following conclusions could be inferred. There seems to be a relationship between teachers' pedagogical beliefs and their use of educational technology in the Mathematics classroom but the nature of this relationship is not clearly defined.

As previously mentioned, Haciomerglu, Bu and Hacciomerglu (2010), Pierce and Ball (2009) and Güven, Akken and Cakiroglu (2009) found that teachers with traditional beliefs (in this study referred to as teaching-centred beliefs) have negative attitudes towards the integration of educational technology in their classrooms, as they believe that pen and paper methods helped learners better grasp basic skills. This study did not investigate teachers' attitudes but rather the teachers' pedagogical beliefs, but also found that the teachers with

teaching-centred beliefs did not fully integrate educational technology in their teaching practise. These teachers with teaching-centred beliefs were more likely to not use educational technology even though they were trained and equipped to do so.

When it came to teachers with learning-centred beliefs, the findings also coincided with some of the literature. Chrysostomou and Mousoulides (2009) and Becker and Riel (2000) also found that teachers that focus on the promotion of problem solving skills and the promotion of a deeper understanding of the content, were more likely to integrate educational technology in their classrooms.

5.1.2 *HOW DO THE FINDINGS FIT IN WITH CURRENT LITERATURE?*

Most of the current research addresses either pedagogical beliefs or the use of educational technology in the classroom but few address the two aspects together. Ertmer (2005) identified that pedagogical beliefs might be an influential factor when it comes to the use of educational technology in the classroom.

This study showed to some extent that pedagogical beliefs do play a role when teachers have to choose to use educational technology or not. This study also coincided with current research that states that teachers with teaching-centred beliefs would use educational technology for supportive use and teachers with learning-centred beliefs use educational technology for class use (Haciomeroglu, Bu, & Haciomeroglu, 2010; Pierce & Ball, 2009; Güven, Akkan, & Cakiroglu, 2009; Chrysostomou & Mousoulides, 2009; Becker & Riel, 2000).

However, contradictions to the current literature have also been identified. Van Braak, Tondeur and Valcke (2004) distinguished teachers' use of educational technology under two main categories, class use [2] and supportive use[3], and stated that teachers will fall within either of these two categories. This study was based on this premise but revealed that this is not the case. The study revealed that teachers based in schools rich in technology are expected to use the technology available to them for supportive use purposes. Teachers

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[2] The use of educational technology for the promotion of learning new subject content
[3] Using educational technology for administration purposes

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were expected to communicate with the parents via email, to calculate and present their mark sheets using technology, etc. One can therefore not categorically place teachers in either of the categories but rather simply explore the extent to which they are using the educational technology for class use purposes. No research has explored multiple facets of technology use and therefore a gap in the research causes limitations in the study.

5.1.3 *HOW DOES THE FINDINGS CONTRIBUTE TO THE GREATER BODY OF KNOWLEDGE?*

This study has revealed aspects previously overlooked by other research. There seemed to be a discrepancy as to what teachers thought was interactive use of technology and what actually was defined as interactive technology use. The teachers would pronounce themselves as interactive technology users but, when observed, were clearly not. Therefore, teachers might want to develop better integration skills if they were offered the opportunity.

The study also revealed that only two of teachers taking part in the study could be described as teachers with completely teaching-centred beliefs or completely learning-centred beliefs. Teaching has evolved and, therefore, there are various levels of teaching-centred beliefs and learning-centred beliefs.

5.2   LIMITATIONS OF THE STUDY

The framework of the study seemed to limit the findings of the study. The teachers' pedagogical beliefs could only fall within four categories and their technology use could only fall within two categories. This limited the accuracy of the findings as most of the teachers demonstrated characteristics of all the categories and therefore complicated the process of placing them within a certain category.

Data could have been collected from more teachers in different technology rich schools. More classroom observations might have helped to clearly establish the teachers' pedagogical beliefs. It might also have allowed the teachers to demonstrate different skills

on different occurrences as teachers might have been busy with a subject that was difficult to integrate educational technology with.

The trustworthiness of the data could also be compromised, as the participants might have fallen victim to the Hawthorne effect. The participants might have used the educational technology in their classrooms differently to how they would use it in normal circumstances as they were aware that the researcher was specifically paying attention to their technology integration.

5.3   RECOMMENDATIONS FOR FUTURE RESEARCH

Based on the above, the following recommendations could be made for future research. It might be helpful to explain certain definitions to the teachers prior to the interview, so that they are clear as to what is being asked with specific reference to the interactive use of technology. Examples of exemplary technology users could be given to thoroughly explain what is meant, before teachers are interviewed. A pre-interview can be used to define terminology and to sort out all minor discrepancies to ensure quality of data. This might lead to more accurate answers and less discrepancies as to what is said and what is done in class.

In future studies more classroom observations are recommended. Technology integration is much more difficult in the subject of Mathematics and some topics allow for better technology integration than others. Therefore the one observation that was made might be made on a day the lesson did not allow for technology use or for the teacher to show that they do follow through with their beliefs. Regular observations over a period might eliminate this occurrence and might help form a better rounded picture of the teachers' beliefs.

An expansion on the technology use framework is also recommended. As previously mentioned it was clear in the study that teachers in schools rich with technology will be required to use their technology for supportive use. The question is rather whether they use it for supportive use only or for supportive use and class use, and if they use it for class use, to what extent are they integrating the educational technology to enhance a learners' learning experience.

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APPENDICES

APPENDIX 1 – LETTER TO PRINCIPAL

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Department Science, Mathematics &
Technology Education

21 May 2013

Dear Headmaster/Principal

RE: REQUEST FOR PERMISSION TO DO RESEARCH IN YOUR SCHOOL

My name is Jaun-Mari Moraal, and I am a master's student in education at the University of Pretoria. I am conducting research on teachers' pedagogical beliefs (how they believe Mathematics should be taught) and their technology use under the supervision of Dr J. Mwambakana. I invite you to consider letting me conduct my research at your school and therefore giving your permission that the Mathematics teachers at the school take part in the study. This study will meet the requirements of the Research Ethics Committee of the University of Pretoria and therefore the anonymity and confidentiality of your school is ensured. Your school will also receive a copy of the final report.

The study involves exploring the relationship between secondary school Mathematics teachers' beliefs and their technology use in the classroom. In order to research this topic I will require 2 Mathematics teachers from every grade to take part in an interview that will take between 30 and 40 minutes. These interviews will take place after school at a location and time fitting to both the teacher and I. As part of my data collection plan, I will also require to make one classroom observation for each teacher taking part in this study.

If you have any questions with regards to the study please do not hesitate to contact me.

Kind Regards

Jaun-Mari Moraal
082 555 8999
jaunmari@gmail.com

Principal's signature:_____ Date: _____

Researcher's signature: _____ Date: _____

Supervisor's signature:_____ Date: _____

Natural Science Building, Room 2-16   Tel number: 012 420 5659
Groenkloof Campus, University of Pretoria   Fax number: 012 420 5621   www.up.ac.za/education
PRETORIA 0002
Republic of South Africa

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APPENDIX 2 – TEACHER CONSENT LETTER

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Department Science, Mathematics &
Technology Education

21 May 2013

Dear Participant

RE: REQUEST FOR CONSENT TO PARTAKE IN RESEARCH STUDY

You are invited to participate in a study aimed at exploring the relationship between secondary school Mathematics teachers' pedagogical beliefs and their technology use in the classroom.

WHAT DOES THIS MEAN?
These days Mathematics classrooms are equipped with all sorts of technology, just to name a few, from interactive whiteboards, data projectors, advance graphing calculators, mathematical (graphical) software like *Geogebra* and a laptop for almost every teacher. Some Mathematics teachers make use of some of the above named technology in their teaching others do not. This study will investigate to what extent teachers' pedagogical beliefs (how they believe Mathematics should be taught) influence the way they use the technology at their disposal.

WHY PARTICIPATE IN THE STUDY?
By participating in this study we will be able to gain a better understanding of the relationship between teacher's pedagogical beliefs and their technology use in their classrooms. This can lead to better strategies in trying to help teachers incorporate technology more confidently in their teaching.

WHAT ABOUT MY SAFETY?
By participating in this study your safety is a number one priority. Your participation in this study is completely anonymous, confidential and voluntary. You do not have to feel obligated to participate in the study and you may withdraw from participating in the study at any time. As a participant you and the schools' identity will be kept anonymous and confidential at all times. Your identity and your schools' identity will not appear in any report nor will your names be mentioned. A report of the study will be submitted to your school and if you would like a personal copy you are welcome to list an e-mail address and I will gladly e-mail you the report.

WHAT DOES THE STUDY INVOLVE?
You will be required to take part in an interview that will take approximately 30-40 minutes. This interview will take place at the school and can be scheduled at a time that best suits you. This interview will be audio recorded to ensure accuracy. I would also like make one classroom observation. It will only be one period and I will not participate in the lesson at any time. I will only be observing to what extent you use the technology in your classroom. If you require a copy of the interview transcripts, I will be glad to send it to you so you can the correct content was transcribed.

If you have any enquiries about the study please do not hesitate to contact me at: 082 555 8999

Participant's signature: _____   Date: _____

Researcher's signature: _____   Date: _____

E-mail Address (If you require a copy of the research report): _____

Kind Regards

_____   _____
Researcher   Supervisor
Jaun-Mari Moraal   Dr. J. Mwambakana

Natural Science Building, Room 2-16   Tel number: 012 420 5659
Groenkloof Campus, University of Pretoria Fax number: 012 420 5621   www.up.ac.za/education
PRETORIA 0002
Republic of South Africa

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APPENDIX 3 – LETTER TO PARENTS INFORMING THEM OF CLASSROOM OBSERVATION

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Department Science, Mathematics &
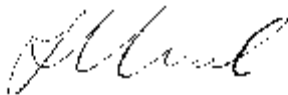**Technology Education**

21 May 2013

Dear Parent/ Guardian

My name is Jaun-Mari Moraal, and I am a master's student in education at the University of Pretoria. I am conducting research on mathematics teachers' pedagogical beliefs and their technology use under the supervision of Dr J. Mwambakana. The study involves exploring the relationship between secondary school Mathematics teachers' beliefs and their technology use in the classroom. In order to research this topic I will be doing some classroom observations.

This letter is to inform you that I will be present in the classroom in one of your child's mathematics lessons. I will not be participating in the lesson, I will only be observing the teacher, and therefore your child is not a participant in the study.

If you have any questions with regards to the study please do not hesitate to contact me.

Kind Regards

Jaun-Mari Moraal
jaunmari@gmail.com

APPENDIX 4 – INTERVIEW PROTOCOL

Interview Protocol

Time of interview: _____   Duration: _____

Date: _____

Place: _____

Interviewer: _____

Interviewee: _____   Pseudonym: _____

Please answer the following / Antwoord asseblief die volgende:

#							
1	Gender/Geslag:	Male/Manlik:	O	Female/Vroulik:	O		
2	Age/Ouderdom:	_____					
3	What grade(s) do you currently teach?	8	O	9	O	10	O
	Vir watter grade gee u skool?	11	O	12	O		
4	Years of teaching experience (excluding this year):	Jare ondervinding (uitsluitend hierdie jaar)	_____				
5	Race/Ras:	Black/Swart:	O	White/Wit:	O	Indian:	O
		Coloured/Kleurling	O	Other/Ander (please specify):		_____	
6	Highest Qualification/ Hoogste kwalifikasie:	Diploma:	O	Bachelor's Degree	O	Master's Degree:	O
		Doctoral Degree:	O	Other (please specify):		_____	
7	Position at School/ Posisie by die skool:	Teacher/ Onderwyser:	O	Grade Head/ Graad Hoof:	O	Head of Department (HOD):	O
		Vice-Principal/ Adjunkhoof:	O	Principal/ Hoof:	O		

Please answer the following / Antwoord asseblief die volgende:

8. How do you help the learners achieve the desired learning outcomes? / Hoe help u die leerders om die verlangde uitkomstes te bereik?

9. How do you expect the learners to use the knowledge one day? / Hoe verwag jy die leerders om hul kennis eendag te gebruik?

10. Who do you think is responsible for organising the content of Mathematics, you or the learner? Please elaborate. / Wie dink jy is verantwoordelik vir die organisering van die inhoud van Wiskunde, jy of die leerder? Brei asseblief nog uit.

11. How do you think a learner's knowledge is constructed?/ Hoe dink jy word 'n leerder se kennis gekonstrueer?

12. How do you incorporate a learner's pre-conceptions about Mathematics in your teaching? / Hoe inkorporeer jy 'n leerder se voorafgaande persepsies oor Wiskunde in jou onderrig strategie?

13. If you can give a ratio of teacher to learner, of who speaks the most in the class (this is about the content not naughty kids), what would it be? / As jy 'n verhouding kan gee van onderwyser tot leerder, wie praat die meeste in die klas? (dit is nou oor inhoud nie stoute leerders nie)

14. Who decides the content of the lesson, you or the learner? Can you please elaborate? / Wie besluit oor die inhoud van die les, jy of die leerder? Kan jy asseblief uit brei?

15. Who do you think should be more motivated in the classroom, you or the learner? Can you please elaborate? / Wie dink jy moet meer gemotiveerd wees in die klaskamer, jy of die leerder? Kan jy asseblief uit brei?

Do you use technology for: Gebruik jy tegnologie vir die volgende:		
	YES/JA	NO/NEE
16 Keeping an agenda and meeting minutes on the computer Om 'n agenda en notules van vergaderings te hou op die rekenaar	O	O
17 Administration, such as letters and reports Administrasie, soos briewe en verslae	O	O
18 Encouraging collaborative learning Aanmoediging van samewerkende leer	O	O
19 E-mail for your job E-pos vir jou werk	O	O
20 Differentiation in the mathematical content Differensiasie in wiskundige inhoud	O	O
21 Looking for information on the Internet for lesson preparation and maths exercises Die soek van informasie op die internet vir les voorbereiding en wiskunde oefeninge	O	O
22 Encouraging pupils to train their mathematical skills Om leerders aan te moedig om hul wiskunde vaardighede te oefen	O	O
23 Looking for educational software like geogebra Om opvoedkundige sagteware soos geogebra te soek	O	O
24 Pupils' completion of their assignments and projects Voltooing van leerders se take en projekte	O	O
25 Demonstrating certain mathematical problems Demonstrering van sekere wiskundige probleme	O	O
26 Preparing worksheets for the pupils Opstelling van werkkaarte vir leerders	O	O
27 (Co-)constructing a school website Die mede-bou van die skool webblad	O	O
28 As an interactive tool for instruction As 'n interaktiewe instrument vir instruksie	O	O
29 Tracking students' progress Leerders se vordering dop te hou	O	O
30 Encourage pupils to search for information on the Internet Om leerder te motiveer om informasie te soek op die internet	O	O
31 Calculating pupils' test scores Om leerders se punte te bereken	O	O
32 Teaching about the possibilities of using computers in a mathematical environment Die leer van moontlike gebruike van tegnolgie in 'n wiskundige omgewing	O	O

THE END

APPENDIX 5 – OBSERVATION PROTOCOL

OBSERVATION PROTOCOL

Topic of study: The relationship between teachers' pedagogical beliefs and their use of educational technology in the Mathematics classroom.

Classroom number:

Pseudonym:

Name of observer: Jaun-Mari Moraal

Date of observation:

Time of observation:

Length of observation:

Non-participatory classroom observation
The observer must be as unobtrusive as possible during the lesson. Avoid distracting the students by staying out of the spotlight as much as possible. Avoid interacting with the students in a way that takes their attention away from the lesson. Definitely avoid the urge to help the students with the activities or assignments.
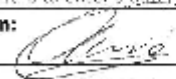
TOPIC TO BE OBSERVED:	OBSERVATION:
What educational technology does the teacher use during the lesson:	
What does the teacher use the educational technology for:	
How do the learners interact with the educational technology?	
How is the educational technology used to enhance the learners' understanding of the topic explained?	
Is the use of educational technology effective within the lesson?	
Any additional notes:	

APPENDIX 6 – RESEARCH DEFENCE OUTCOME

FACULTY OF EDUCATION

RECORD OF DOCTORAL AND MASTER'S PROPOSAL DEFENCE:

This form records the status and performance of MEd students at their scheduled defence.

DATE OF DEFENCE: 2012/11/05		Student number: 26114829	
STUDENT NAME: Jaun-Mari Moraal		DEPARTMENT: SMTE	
SUPERVISOR	Dr Mwambakana	Co-SUPERVISOR	Dr Stols
CRITICAL READER	Dr Mnguni	CRITICAL READER	Ms Kazeni

PROPOSED TITLE

The influence of teachers' pedagogical beliefs on their technology use in the mathematics classroom

MAJOR COMMENTS MADE ON PROPOSAL: (This list is not exhaustive, see attached comments)

1. Rationale, aims and objectives and problem statement should be revisited. Substantiate and justify your choices.
2. Research questions should be reconsidered as discussed in the defence meeting.
3. Methodology: Sequence of sections in the document should be changed. Sample size must be reconsidered and the sample must described in more detail. Data analysis strategies must be aligned with research questions. Reconsider the data collection strategies.
4. Methodological norms must be aligned to the data collection strategy.
5. The timeline is optimistic and should be reconsidered in line with the constraints that exist.
6. Technical and language editing should be attended to.

OUTCOME:

1 = Approved ☐

2 = Conditionally approved (candidate to make minor revisions to RP to the satisfaction of his/her supervisor) ☐

3. = Conditionally approved (candidate to make major revisions to RP to satisfaction of supervisor) ☒

4. Not approved (need to defend again or resubmit to the supervisor, chair of proposal defence and one other academic) ☐

5. Failed (registration terminated) ☐

TITLE REGISTERED:

YES ☐

Date registered: Click here to enter a date.

No: ☒

Date to be submitted: Click here to enter a date.

ETHICS STATEMENT:

Submitted: YES ☐ NO ☒

Attached: YES ☐ NO ☒

RESEACH SCHEDULE:

Submitted: YES ☐ NO ☒

Attached: YES ☐ NO ☒

To be submitted (date): Click here to enter a date.

CHAIRPERSON OF THE DOCTORAL OR MASTERS DEFENCE COMMITTEE	Name: Dr Abrie	Sign:

NOTE: Copies of this form must be submitted to:

- o Student Administration, which will officially inform the student of the outcome of the doctoral/masters proposal defence
- o The Chairperson of the Faculty Ethics Committee
- o The Co-ordinator of the Doctoral/Masters Programme of the Faculty
- o The Supervisor of the student