A cross-country comparison of mathematics teachers' beliefs about technology, pedagogy and content knowledge

by

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Submitted in partial fulfilment in accordance with the requirements for the degree

PHILOSOPHIAE DOCTOR

in the Faculty of Education

at the

UNIVERSITY OF PRETORIA

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NOVEMBER 2018

Declaration

I, Mothobi Neo Jack, student number 25354371, declare that the thesis, which I hereby submit for the degree Doctor of Philosophiae at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution. All sources cited or quoted in this research paper are indicated and acknowledged with a comprehensive list of references.

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DEGREE AND PROJECT	PhD (CIE) A cross-country comparison of mathematics teachers' beliefs about technology, pedagogy and content knowledge
INVESTIGATOR	Mr Neo Mothobi
DEPARTMENT	Science, Mathematics and Technology Education
APPROVAL TO COMMENCE STUDY	14 July 2015
DATE OF CLEARANCE CERTIFICATE	12 February 2018

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Ethics Statement

The author, whose name appears on the title, has obtained, for the research described in this work, the applicable research ethics approval. The author declares that he has observed the ethical standards required in terms of the University of Pretoria's code of ethics for research and policy guidelines for responsible research.

Dedication

- I would like to express my sincere gratitude to the Heavenly Father, who provided me with the wisdom and strength, knowledge, perseverance and strength to enable me to complete the study.

- Most importantly, none of this would be possible without the love and patience of my family.
    - My four sisters and their families for their unwavering support, understanding and patience;
    - My partner Modiegi and Remofilwe (son) whom this thesis is dedicated to, have been a constant source of love, concern, support and strength all these years. I would like to express my heartfelt gratitude to them.

- My very special thanks are due to the one person whom I owe everything I am today, my late mother, Motsei Mothobi. Her unwavering faith and confidence in my abilities and in me is what has shaped me to be a person I am today. Thank you.

Acknowledgements

There are many things that one can do, but most of them one cannot accomplish alone. I owe my gratitude to all those people who have made this thesis possible because of whom my graduate experiences has been one that I will cherish forever.

- My deepest gratitude goes to Prof. L. van Ryneveld (supervisor) and Dr. M.A. Graham (co-supervisor) for their immeasurable and valuable intellectual input, advice and guidance when I needed them.

- Many friends have helped me stay sane through these difficult years. Their support and care has helped me overcome setbacks and stay focussed on my research. I greatly value their friendship and deeply appreciate their belief in me.

- My deepest gratitude goes to my previous supervisor, the late Professor Dr.J.G Knoetze. He taught me how to question life and express my ideas. His patience and support has helped me to overcome many crisis situations; and

- Anetha de Wet for the language editing of this thesis.

Abstract

The purpose of this study was to determine how South African learners compare with their selected international counterparts according to their teachers' views (Saudi Arabia, Sweden, Norway, Thailand, United Arab Emirates and Singapore). The analysis was based on the three predictor variables namely computer activities, teaching strategies as well as teaching specific mathematics content. These three predictor variables were extracted from the TIMSS 2011 teachers' datasets and linked to the learners' data. Furthermore, these predictor variables were analysed in a multicultural comparison. It should be taken into cognisance that the selection of the items, from the teacher questionnaire, were informed by the TPACK theoretical framework. The learners' data was examined using factor analysis and orthogonal factor rotation. The Tucker congruent coefficient was used to determine the similarity between learners in South Africa and each of their selected international counterparts according to their teachers' viewpoints.

In this study, similarity does not imply being totally identical, but rather demonstrates which teachers responses between South Africa and each of the countries compared with might have the same structure after the statistical analysis. The results from the analysis revealed that regardless of the socio-economic status between South Africa and each of the countries compared with, it could be claimed that some similarities can be fostered. The differences in teachers' beliefs between South Africa and all the countries analysed provided vital information about the scope of possible classroom practice and teachers' inclination to different teaching approaches. These results are based on the teachers' beliefs revealed in which ways various teaching and learning strategies are conceptualised in different countries.

Key terms: TPACK framework, Diffusion of Innovation theory, teachers beliefs, congruent coefficient, orthogonal rotation and CATPCA.

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25 April 2018

TO WHOM IT MAY CONCERN

This is to confirm that the thesis titled ***"A cross-country comparison of mathematics teachers' beliefs about technology, pedagogy and content knowledge"*** by Neo Jack Mothobi was proof read and edited by me in respect of language.

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List of Abbreviations

ALS	Alternating Least Square
ANA	Annual National Assessment
CATPCA	Categorical Principal Component Analysis
CFA	Confirmatory Factor Analysis
CK	Content Knowledge
CoP	Community of Practice
DBE	Department of Basic Education
DoE	Department of Education
DoI	Diffusion on Innovation
EFA	Exploratory Factor Analysis
ERIC	Education Research Information Centre
FET	Further Education and Training
FIMS	First International Mathematics Study
GDP	Gross Domestic Product
GET	General Education and Training
GoL	Gauteng Online
IBM	International Business Machine
ICT	Information and Communication Technologies
IDB	International Database Analyzer
IEA	International Association for the Evaluation of Educational Achievements
IRT	Item response theory
IWB	Interactive Whiteboards
KMO	Kaiser Meyer-Olkin
LINCAS	Large-scale International Comparative Studies
MAR	Missing at random
MCAR	Missing completely at random

MDS	Multidimensional Scaling
MNAR	Missing not at random
MST	Mathematics, Science and Technology Education Strategy
MTQ	Mathematics Teacher Questionnaire
NCS	National Curriculum Statement
NRC	National Research Coordinators
OECD	Organisation of Economic Co-operation and Development
PC	Percent-correct format
PCA	Principal Component Analysis
PCK	Pedagogical Content Knowledge
PISA	Programme for International Student Assessment
PK	Pedagogical Knowledge
PPP	Purchasing power parity
PSMTs	Pre-service Mathematics Teachers
PVAF	Percentage of variance accounted for
QIRC	Questionnaire Item Review Committee
RMSD	Root-mean-square-deviation
SACMEQ	Southern and East African Consortium for Monitoring Quality
SDA	Secondary Data Analysis
SIMS	Second International Mathematics Study
SITES	Second Information Technology in Education Study
SPSS	Statistical Package for the Social Sciences
SRm	Systematic review methodology
TCK	Technological Content Knowledge
TIMSS	Trends in Mathematics and Science Study
TK	Technological Knowledge
TPACK	Technological Pedagogical Content Knowledge
UNESCO	United Nations Educational Scientific and Cultural Organisation

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CHAPTER ONE: BACKGROUND OF THE STUDY

1.1 Introduction

Since 1994, South Africa has been part of the global community and this has opened many avenues for its citizens. These avenues consist of educational opportunities, access to employment, business opportunities as well as world-class information and communication technologies (ICTs). However, the participation of South Africa internationally has brought numerous challenges to its education system and economy. It has been argued that the South African education system has been continuously transforming in relation to the development of the 21st century learning outcomes (Law & Chow, 2008). Through the development of the 21st century skills, learners are provided with necessary skills and knowledge to be able to participate with their counterparts globally.

Being a global competitor, South Africa has been part of the four (1995, 1997, 2003 and 2011) Trends in Mathematics and Science Study (TIMSS) assessments conducted by the International Association for the Evaluation of Educational Achievements (IEA). These studies (TIMSS) are conducted on a fixed four-year interval to evaluate fourth and eighth grade learners' competencies in mathematics and science (Mullis et al., 1997). The TIMSS studies are based on the comparison of curricula coverage and teaching practices and are linked with the students' achievements (Mullis, Martin, Gonzalez, & Chrostowski, 2004). The TIMSS international comparative studies are grounded on an effort to understand various education systems.

Indeed, TIMSS international comparative studies are important in view of the fact that they provide scholars and governments with relevant information to understand learner performance (Plomp, 1998). These international comparative studies, such as TIMSS, have compelled countries across the world to provide schools with appropriate educational resources to accelerate and improve the quality of basic education. Various countries globally are continuously using these international comparative studies to reorganise and set out new priorities for their education systems (Mullis, Martin, Foy, et al., 2008). Furthermore, these studies have offered novel ways of thinking to participating countries on how to improve learner achievement in their schooling systems.

Educationists have further taken notice that scientific and technological expertise form part of learner prosperity. It is vital that teachers should change their pedagogical, content and technological knowledge that may have worked in the past decades, but have little impact in 21st century classrooms (Mishra & Koehler, 2006). Furthermore, in order to find the most effective solution to improve learner performance, it is imperative for teachers to ascertain the basis of the perceived performance gaps. It is therefore not only vital to understand contemporary learning theory but also to identify those application technologies that can contribute to the optimising of instruction and learning in new learning milieus.

1.2 Background of the study

South Africa is faced with various educational challenges that were created prior to 1994 by the apartheid government. Some of the school buildings are dilapidated and few educational resources are allocated to public schools (Gibberd, 2007). Allocations of educational resources as well as ICT infrastructure are viewed as the basic requirements by government (Department of Education, 2004). However, poor allocation of resources is exacerbated by the competing priorities at school level in some provinces. This poor allocation of resources has perpetuated the gaps that exist in the South African schooling system.

Reports released by the Department of Education (DoE) show that the number of learners passing mathematics at Grade 12 level in South Africa has not increased as expected (DoE, 2002). This is evident from the results released annually by the DoE which indicates a decrease in the number of learners passing mathematics in Grade 12. In 2001 the DoE developed and released the Mathematics, Science and Technology Education (MST) Strategy (DoE, 2001). The main objective of the MST strategy was to address poor mathematics, science and technology results of graduates in Grade 12. Furthermore, this strategy was also aimed at maximising learning and improving learner performance in mathematics, science and technology from Grade 1 to 12.

In an effort to curb the dwindling number of learners enrolling for mathematics in Grade 12, the DoE introduced mathematical literacy as an additional subject (Department of Education, 2006). Statistics released annually during the announcement of Grade 12 results have shown a slight increase in the number of learners passing the National Senior Certificate due to this intervention.

1.3 Rationale of the study

The uptake of TIMSS in South African schools has not increased drastically especially taking into consideration that there are more than 25 851 ordinary public schools as part of the basic education system. There were 19 444 (75.2%) schools with a population of 8 321 156 (67.7%) learners and 274 174 (65.2%) educators (Department of Basic Education, 2013, p. 3). These South African schools have Grade 4 and Grade 8 as two of the grades that TIMSS examine every four years.

In South Africa statistics have proven that learners in General Education and Training (GET) and Further Education Training (FET) bands have poor grades in mathematics (DBE, 2012). This is apparent in mathematics when learners are involved in activities that require them to solve abstract problems. The results from TIMSS international assessments indicate that the performance of South African learners is still at the lowest level when compared to other countries globally (Martin, Mullis, Foy, & Stanco, 2012; Mullis et al., 1997). Indeed, similar sentiments are shared by Howie (2004), namely that South African learners are underperforming when compared to their international counterparts. Even in 2011, the results published by the IEA pointed out that South Africa was ranked the lowest in terms of learner's performance amongst the developing countries (Mullis, Martin, Foy, & Arora, 2012).

It is due to the poor achievement of South African learners in mathematics, when compared to other countries, that this study is undertaken. It is based on the analysis of the TIMSS 2011 dataset that is the fifth trend measure conducted by the IEA since 1995. This is a quantitative study aimed at determining how South African learners compare with their international counterparts based on their teachers' viewpoints. According to Grønmo, Pavešić, Nyström, and Onstad (2013), comparative studies are conducted in order to provide countries with a reflection on their education systems and practices. Therefore, to compare in this research means to distinguish similarities and variances between two or more countries.

For South Africa TIMSS was administered at Grade 9 level, rather than the Grade 8 level, since TIMSS argued that the countries should all be at about the same performance level for the comparisons to be fair. (Mullis, Martin, Foy, et al., 2012).

1.4 Problem statement

The achievement of learners in mathematics continues to attract attention from the general public, policy makers and researchers globally (Mullis et al., 2004). Looking at the underlying importance of mathematics to educational and economic opportunities, putting much emphasis on this subject is unavoidable and hence acceptable. The low levels of learner performance in mathematics and science remain a serious concern for different countries worldwide (Mullis, Martin, Foy, et al., 2012). It is evident that schooling systems worldwide are faced with major challenges concerning the instruction and learning of mathematics in the entire education system.

Mathematics teaching and learning in the South African schooling system are struggling based on the wide range of national and worldwide research. A wide range of research indicated that there is a need for addressing the challenges of mathematics education, namely mathematics knowledge for teaching (Adler, 2005) and improving teaching pedagogies (Venkat & Naidoo, 2012; Hoadley, 2012).

Furthermore, Sime and Priestley (2005, p.131) pointed out that “although teachers in schools show great interest and motivation to learn about the potential of Information Communication Technology (ICT), in practice, use of ICT is relatively low and it is focused on a narrow range of applications”. Therefore, a combination of these strategies and related interventions needs to be investigated if the South African schooling system seeks to forge ahead in turning this crisis around. While the global debate on technology use in education thus continues, the South

African government is exploring the integration of technological tools in the classroom. It is against this background, that the following question can be asked: “if technology is regarded as a tool to enhance teaching and learning, why mathematics teachers in South Africa not making optimal use of technology in their classrooms?

It has been argued that the quality of teaching and learning depends on the knowledge the teacher brings to the classroom (Rowland & Ruthven, 2011). It is in this context that a study focusing on teachers’ viewpoints related to classroom practices is imperative because it will reveal the comparative achievement of various countries worldwide. Deductions could be made on the relationships between a number of factors in learning situations, such as teachers’ beliefs, classroom practices, allocation of resources and teachers’ experiences. These connections could be used in other countries for possible argumentation in students’ performance.

1.5 Framework used in this study

There is a need for teachers to develop their technological skills in order to integrate technology in mathematics classrooms (Mishra & Koehler, 2006). It is therefore imperative for teachers to have the requisite knowledge regarding technology, content and instruction. Furthermore, teachers are required to possess technological, pedagogical and content knowledge to be able to teach learners mathematical principles and concepts in a technology-enabled environment.

Hew and Brush (2007) indicated that numerous approaches have been developed and implemented in order to assist teachers to triumph over many challenges associated with the infusion of technology, to improve teaching and learning. According to Koehler and Mishra (2009, p. 66), the novel way of providing and supporting teachers in the integration of technology into the mathematics classrooms, is putting into practice the Technological Pedagogical Content Knowledge (TPACK) framework. The TPACK framework, as suggested by Mishra and Koehler (2006), outlines the three knowledge forms (content, pedagogy and technology) that teachers should possess in order to integrate and use technology as a tool in their classroom instructions.

This research underpins the influence of teacher knowledge to teach mathematics with technology, in order to bolster student achievement in mathematics. As a quantitative research study, the TPACK framework was used to explore the effects of teachers' content knowledge, content coverage as well as the use of technology in order to enhance student's achievement in mathematics. In essence, the use of computers to deliver curriculum content differs significantly among mathematics teachers, as do their personal propensity to undertake learning efforts. It is these variations that lie at the focal point of the problem areas suggested for this study. If a relationship can be found between computer usage, pedagogy and content coverage, then it might be feasible to look towards TPACK as an approach for advancing a higher quality of teaching and learning.

1.6 Purpose of the research

The purpose of this study is to explore how South African learners compare with their international counterparts according to their teachers responses during the TIMSS 2011 study. The relationship is deduced by comparing teachers' opinions regarding the use of computer activities, teaching strategies, as well as the teaching of specific mathematics content. It should be noted that the sampling for the teachers' who completed the questionnaire was based on the participating students (Mullis et al., 1996). Therefore, it is important for the reader to take into cognisance that in this study the learner is used as the unit of analysis even if the information from the teachers' questionnaire is reported.

It has been argued that teachers regulate how much time will be dedicated to a subject at hand and they also decide on which areas the focal point of student learning will be (Schwille et al., 1983). Furthermore, borrowing from the results of the analysis of students' achievements and teachers' classroom teaching, it is indicated that "teachers are crucial to students' opportunities to learn mathematics, and substantial differences in the mathematics achievement of students are attributable to differences among teachers" (Ball et al., 2008, p. 7).

Furthermore, it should be noted that this is a secondary study, analysing learners' data according to their teachers' responses emanating from the TIMSS 2011 study. Secondary data analysis (SDA) signifies the analysis of the readily available data that was collected and stored by a different researcher for similar or different purposes (Grinyer, 2009; Smith, 2008). Various authors alluded to the fact that the TIMSS datasets have encouraged and provided researchers with an avenue to conduct a vast amount of secondary data analyses studies (Robitaille & Beaton, 2002; Vandecandelaere, Speybroeck, Vanlaar, De Fraine, & Van Damme, 2012).

The analysis of this data has provided educationists with a wealth of information encompassing the instructional methods, curriculum coverage and the use of computer activities employed by teachers to improve learner attainment in mathematics and science instruction. The TIMSS international databases contain valuable indicators about school, mathematics, science, teachers' and learners' information to support secondary analyses (Haertel, 1997). Numerous secondary data analysis studies have been conducted by researchers using the stored data available on the TIMSS website (Lassibille & Navarro, 2000).

1.7 Research questions under investigation

Taking into account the views from Zikmund (2003), the formulation of a research question is aimed at clarifying the problem statement of the proposed study. Therefore a research question is regarded as the translation of the problem statement into a detailed and systematic process for analysis. The research questions that form part of this study are as follows:

Research question 1

How do South African learners compare with their selected international counterparts with regards to how their teachers have **used various computer activities**?

Research question 2

How do South African learners compare with their selected international counterparts with regards to how their teachers have used different **teaching strategies**?

Research question 3

How do South African learners compare with their selected international counterparts with regards to their teachers preparedness to teach **specific mathematics content**?

1.8 Statistical techniques used in this study

In this research various statistical procedures were utilised to process and analyse data collected from the TIMSS 2011 dataset. Firstly, a dimensionality reduction technique was used to determine whether the selected items are suitable for factor analysis. Secondly, a statistical technique referred to as Categorical Principal Component Analysis (CATPCA) was used to decrease the measurements of the original set of categorical variables (learners data linked to their teachers' responses) into smaller sets of quantitative variables (International Business Machine Corporation, 2012; Krol, Veenman, & Voeten, 2001). Thirdly, procrustean rotation was used to rotate the factor loadings (teaching strategies, use of computer activities and content coverage) of South Africa to be similar to the factor loadings of each of the selected countries. Lastly, the Tucker congruent coefficient (Lorenzo-Seva & ten Berge, 2006) was used to estimate whether there is significant similarities between South Africa and their selected international counterparts as follows:

a) Values greater or equal to 0.95

If the Tucker congruent coefficient is **greater than or equal to 0.95,** then it will be established that there are **similarities** between South African learners and each of the countries that were selected in this study regarding how their teachers have used *computer activities, teaching strategies,* as well as their preparedness to teach *specific mathematics content*.

b) <u>Values lower than 0.95</u>

If the Tucker congruent coefficient is **less than 0.95**, then it will be established that there are **no significant similarities** between South African learners and each of the countries that were selected in this study regarding how their teachers have used *computer activities, teaching strategies*, as well as their preparedness to teach *specific mathematics content.*

1.9 Significance of the study

This research provides empirical evidence about how South African learners compare with their selected international counterparts. This study offers an insight into how computer activities, teaching strategies, as well as content coverage, can be compared between countries by making use of different statistical techniques. In addition, this study is aimed at providing practitioners with another lens through which the TIMSS studies can be analysed and interpreted as well as an avenue to assist researchers who intend using the TPACK framework to analyse teachers' opinions.

Finally, it is hoped that this research contributes new knowledge to the body of research findings that exists on the thesis at hand, as well as on how various statistical procedures can be used to compare TIMSS learners' data that is linked to their teacher's responses. The scholars and the research community, who are in similar contexts, might benefit from the pronouncements of this study in their quest to analyse teachers' competencies.

1.10 Assumptions of the study

This study is based on the assumptions that:

1) Grade 8 and Grade 9 mathematics teachers, who participated in the TIMSS 2011 study, have completed and provided their true opinions about:
    - ❖ How they have used computer activities in teaching and learning of mathematics as well as the administration thereof;
    - ❖ Teaching strategies used in the teaching and learning of mathematics; and
    - ❖ Mathematics content covered in the selected TIMSS classrooms.

2) Learners in all the countries that are selected for this study where linked and taught by teachers who completed the questionnaire.
3) The statistical techniques employed in this research will provide the reader with a clear picture about the Grade 8 and Grade 9 learners' data according to their mathematics teachers' responses during TIMSS 2011.

1.11 Advantages and disadvantages of using secondary data

The use of secondary data as the sole source or as a supplement or pilot to enhance future data collection must be justified (Shultz, Hoffman & Reiter-Palmon, 2005). Table 1:1 presents the advantages and disadvantages of existing data.

Table 1:1 Advantages and disadvantages of using secondary data

Advantages	Disadvantages
• Saves resources such as time and money	• Overall quality of data
• Assists the researcher to circumvent data collection problems	• Appropriateness of data to address the research question
• Allows a variety of research design	• Stagnation of theory
• The data can be used in a pilot or exploratory study	• Unique statistical skills are required to analyse secondary data
• The stored data is in the SPSS or SAS format	• Detecting errors is often difficult when using the stored data
• Organisation may be more open to using existing data versus collecting new data	• Misconception that quick and easy research can be conducted
• Availability of international or cross-cultural data	• Failure of novice researchers to develop skills required in planning and conducting data collection

Adapted from Shultz, Hoffman and Reiter-Palmon (2005)

Any research study commences with an extensive review of the literature when using existing or new data. Therefore, the existing data could be used in its entirety or as a supplement to collecting new data, to adequately address the research question under investigation (Shultz et al, 2005). Therefore, it is important for researchers to weigh the advantages and disadvantages of existing data as outlined in Table 1:1 to determine if, for a particular situation, it makes sense to employ existing data (Shultz et.al, 2005).

1.12 Delimitation of the study

The study is limited to the TIMSS 2011 data and not all the TIMSS studies conducted prior to 2011 and beyond. This was the most recent dataset available at the time of the investigation. These learners were associated with Grade 8 and Grade 9 mathematics teachers who provided their viewpoints. However, these teachers who provided responses did not represent samples of teachers in the countries that participated during the TIMSS 2011 study. Lastly, due to the nature of the study it is not possible for the researcher to control data collection errors because the data was collected in 2011.

1.13 Reliability and validity

According to Saunders, Lewis, and Thornhill (2007) validity is linked with the correctness and trustfulness of the results, while reliability looks at the reliability of the data collection instrument. The TIMSS Questionnaire Item Review Committee (QIRC) and the TIMSS National Research Coordinators (NRC) conducted the item test analysis of the questionnaires (Mullis & Martin, 2011). According to Mullis and Martin (2011) items that possessed reliable measurement, after the item analysis, were kept by the IEA for the main data collection. In order to reduce the response problems, all items that did not make a contribution to construct measurement or lacked a relationship with student achievement, were not included in the final questionnaires.

1.14 Structure of the thesis

This thesis consists of six chapters and each chapter is summarised in the subsequent paragraphs. Chapter 1 introduces the present study through articulating the purpose and the rationale for conducting this study, as well as the background of the TIMSS 2011, along with the structure of the exploration.

Chapter 2 provides an account of the literature reviewed exploring the TIMSS studies as well as the TPACK theoretical framework adapted for the purpose of this study. Chapter 3 gives details about the research design used in this investigation. It discusses the rationale for the quantitative design of the study, the sampling procedure, the data gathering instrument, the research questions, the ethical safeguards and considerations and the justification for the study. It also describes the procedures of data exploration, as well as the delineation and limitations. Chapter 4 reports on the descriptive statistics and findings of this part of the study. Then Chapter 5 proceeds to report about the inferential statistics related to the relationship between South Africa and each of the countries analysed in this research. Chapter 6 discusses and provides summaries of the findings and draws conclusions. Finally it offers recommendations for further studies.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

We are living in a technological era where a gigantic amount of information is collected and archived by researchers, governments as well as other organisations all over the world (Qin & Li, 2013). The technological advancement in the 21st century is responsible for the enormous volumes of information gathered, compiled and archived that is nowadays within reach for exploration purposes (Johnston, 2014). It is based on these developments that academics have started to realise the reusable nature of information in warehouses for research purposes (Andrews, Higgins, Andrews, & Lalor, 2012; Smith et al., 2011).

Technological innovations have created avenues for researchers to conduct secondary studies using the archived data for a different study purpose. Secondary data analysis (SDA) have evolved over the years as an empirical activity conducted by a new researcher using different research principles than those utilised in the original study (Robert & Brewer, 2003; Smith, 2008). International comparative studies have provided educationists, researchers and policy makers with information on educational outcomes such as curricula and teaching practices (Beatty, Paine, & Ramirez, 1999). Indeed international comparative studies have stimulated immense public interest as it is vividly documented in various publications and public debates (Mullis, Martin, Goh, & Cotter, 2016). Public interest is asserted through the policy statements from international and national organisations supporting the incorporation of digital and non-digital technology into the classroom instructions (Säljö, 2010). For example, the educational policy makers and researchers ascertained how the infusion of technology into teaching and learning can contribute to learners' success globally (Department of Education, 2004).

The international comparative studies are typically designed to compare educational achievements across nations (Gustafsson, 2008; Mullis & Martin, 2006). Furthermore, it should be taken into cognisance that the primary goal of these international assessments are aimed at using the educational system across the world as a laboratory where scientific experiments can be performed (Gustafsson, 2008). As such, mathematics, science and reading comparative studies have been conducted to assess students' performance in many countries worldwide. Due to the fact that this study is based on the existing TPACK model, the literature was reviewed comprehensively in order to attain a good understanding of the researched field. However, it is essential that secondary data should be examined before any primary research can take place (Cheng & Phillips, 2014). This is imperative, because it affords an investigator to scrutinise the data and have an insight in what is already available in order to ensure that the envisaged research will be suitable to accomplish the set objectives (Smith, 2008).

This chapter provides a cursory look into a revolution of the worldwide comparative studies that focuses on education. Furthermore, this paved the way to look into the literature relating to the Programme for International Student Assessment (PISA), the First International Mathematics Study (FIMS) and the Second International Mathematics Study (SIMS) as well as the Trends in Mathematics and Science Study (TIMSS), as examples of these worldwide comparative studies. In addition, this chapter also explored the Technological, Pedagogical and Content Knowledge (TPACK) model as a theoretical framework for the study. Lastly teachers' beliefs were also explored in relation to the purpose of the study.

2.2 Importance of international studies

Various authors suggested that international comparative studies are necessary because they provide information to the following bodies, enabling them to look at the well-being of their education system:

- **Governments** require information about the education systems for which they are responsible, in order to provide resources according to need. Thus the international studies serve as a barometer based on the empirical evidence (Grønmo & Onstad, 2013).

- **National research institutions** use this data to conduct SDA based on the primary findings (Beatty et al., 1999).

- **Schools** are able to use the results and consider the recommendations made for outstanding practices with regards to instructional activities and learner achievements (Mullis et al., 1997; Murphy, 2010; Nelson, 2002).

The international comparative studies have become a key element in the public discourse about how some of the countries' educational systems are thriving, as well as what needs to be done to reform those that are lacking behind (Mullis & Martin, 2006). Furthermore, the worldwide comparative studies of education systems, which include curriculum, governance as well as teacher development, are nowadays widely recognised (Mullis & Martin, 2006; Mullis et al., 2004).

2.3 Overview of international comparative studies

The Organisation of Economic Co-operation and Development (OECD), the International Association for the Evaluation and Educational Achievement (IEA), the World Bank and United Nations Educational Scientific and Cultural Organisation (UNESCO) are some of the organisations that organise and support the international comparative studies that focuses on student achievements (Gustafsson, 2008; Mullis & Martin, 2006). However, other international studies such as the Second Information Technology in Education Study (SITES), are concentrating on the implementation and the utilisation of information technology in primary and secondary education (Law, Pelgrum, & Plomp, 2008).

According to Postlethwaite (1967, p. xvii) comparative studies are defined as the process of examining

> *"two or more entities by putting them side by side and looking for similarities and differences between or among them. In the field of education, this can apply both to comparisons between and comparison within systems of education".*

Table 2:1 indicates a brief overview of the large-scale international comparative studies (LINCAS) conducted in education by the two organisations, namely the IEA and the OECD. These studies are subsidised by governments of the participating countries and the coordinating organisations.

Table 2:1 Overview of international comparative studies

	Name of study			
	PISA	**FIMS**	**SIMS**	**TIMSS**
Purpose	Appraises education systems of different countries	Measures trends in students' achievement based on mathematics	Measures trends in students' achievement based on mathematics	Measures trends in students' achievement based on mathematics and science
Subjects evaluated	Reading, science and mathematics	Mathematics	Mathematics	Mathematics and science
Organisation	OECD	IEA	IEA	IEA
Years conducted	2000, 2003, 2006, 2009, 2012	1964	1980-1982	1995, 1999, 2003, 2007, 2011, 2015
Test scale	Item response theory (IRT)	Percent-correct format (PC)	Percent-correct format (PC)	Item response theory (IRT)
Grade or age	Fifteen year-olds	Thirteen year-olds and final year of secondary school	Thirteen year-olds and last year of secondary school	Grade 4 (average age 9.5) and Grade 8 (average age 13.5)
Results	Ranking countries and regional education systems' students outcomes	Ranking countries using the mean achievement test score	Ranking curricula, instructional practices and students outcomes in a cross-national perspective	Ranking curricula, instructional practices and students outcomes in a cross-national perspective
Type of test	Criterion referenced	Criterion referenced	Criterion referenced	Criterion referenced
Website	http://www.oecd.org/pisa/	http://www.iea.nl/fims	http://www.iea.nl/brief-history-iea-more	http://timss.bc.edu/

The international studies mentioned in Table 2:1, namely the PISA, FIMS, SIMS and TIMSS are explained in the subsequent paragraphs.

2.3.1 Programme of International Student Assessment (PISA)

The Programme for International Student Assessment (PISA) is an investigation conducted by the OECD since 2000 on a three year cycle (Murphy, 2010). This assessment has gone through a number of iterations, the initial PISA assessment was conducted in 2000 focusing on reading, the second survey in 2003 focused on student performance in mathematics, while the 2006 survey focused on scientific literacy (Baldi, Jin, Skemer, Green, & Herget, 2007). The main focus of this triennial assessment is to ascertain the extent to which the fifteen year-olds have acquired knowledge and proficiencies in mathematical, reading and scientific literacy (Turner & Adams, 2007).

2.3.2 First International Mathematics Study (FIMS)

The initial international comparative assessment carried out by the IEA was the First International Mathematics Study (FIMS) in 1964 (Mullis et al., 1997). It is regarded as an experimental study because it provided useful descriptive information on mathematics achievement. The main purpose of FIMS was to compare the outputs of diverse education systems using psychometric techniques (Mullis & Martin, 2006).

According to Howson (1999) FIMS provided guidance on what worked in education and what required rethought. A total of twelve economically developed countries participated in the inception of this study (Australia, Belgium, England, Flanders, France, Germany, Israel, Japan, Netherlands, Scotland, Sweden and the United States). The target population was thirteen year-old learners at the final year of their secondary schooling who were learning advanced mathematics (Mullis et al., 1997).

2.3.3 Second International Mathematics Study (SIMS)

The Second International Mathematics Study (SIMS) is regarded as the second predecessor of TIMSS based on the experiences and the recommendations taken from the FIMS (Mullis & Martin, 2006). SIMS target population were thirteen year-old students and learners at the final year of their secondary schooling who were learning advanced mathematics. A total of twenty countries participated in inception of the SIMS study between 1980 and 1982. The main goal of SIMS was to produce an international picture with a particular emphasis on what actually transpires in mathematics classrooms around the world (Robitaille & Garden, 1989). These authors (Robitaille & Garden, 1989) further spelled out that the SIMS placed immense emphasis on the role of curriculum on students achievement.

2.3.4 Trends in Mathematics and Science Study (TIMSS)

The Trends in Mathematics and Science Study (TIMSS) is the third international study conducted by the IEA from 1995 to date focusing on mathematics and science (Beaton et al., 1996; Gustafsson, 2008). The TIMSS study is regarded as a pioneer because it brought together mathematics and science assessment. The target population for these TIMSS international comparative studies is Grade 4 and Grade 8 learners, respectively, studying mathematics and science in the participating countries. These studies have concentrated on learners' achievements as well as teachers' opinions about the use of computers, curriculum coverage and instructional activities. A total of 45 countries participated at the inception of the TIMSS 1995 assessment, and the number has increased even more over the years.

2.3.5 Conclusion based on the three international studies

It can be deduced from Table 2:1 that the IEA has made a significant contribution regarding the cross national comparison studies since 1964 to date, focusing on learner mathematics achievements. Furthermore, the PISA studies measure the achievements of fifteen year-olds in language, mathematics and science while the TIMSS assessments concentrate on measuring science and mathematics achievement among the fourth and eighth grade students worldwide. Since the inception of these international comparative studies, the number of countries participating has increased drastically from twelve in 1964, to 64 in 2011.

Therefore, the international achievement data is potentially useful to researchers, teachers, policy makers and others interested parties in providing evidence regarding factors that influence student learning (Mullis et al., 2000). It is imperative that researchers and policy communities be aware that the TIMSS investigations are not all-inclusive and, therefore, cannot provide a solution to every question that is posed to an education system (Mullis & Martin, 2011). Furthermore, it is of utmost importance for all stakeholders to be familiar with all the gaps that the TIMSS data and findings present to them, such as teacher quality (Akiba, LeTendre, & Scribner, 2007), allocation of resources and gender (Marks, 2008). Nonetheless, TIMSS results have provided the research community with novel opportunities to have access to valuable information and to spur dialogue concerning which data is needed.

All the countries found in the top half of the TIMSS achievement distribution are the richest countries (with GNI/capita of $20 000 or higher) while many poor countries are at the bottom end of the achievement distribution curve (Mullis, Martin, Minnich, et al., 2012). According to Mullis and Martin (2006) teaching and learning strategies employed in mathematics classrooms all over the world are “remarkably similar”. Since TIMSS 1995, the integration of technology into teaching and learning of mathematics has also emerged as a topic of considerable study (Mullis & Martin, 2006).

2.4 South Africa participation in the international studies

South African schools have been participating in the international comparative studies, such as TIMSS and Southern and East African Consortium for Monitoring Quality (SACMEQ). These studies are explained in the subsequent paragraphs.

2.4.1 TIMSS studies

South African schools have been participating in the TIMSS international studies since 1995 to date. Table 2:2 indicates the average scale scores of Grade 8 and Grade 9 TIMSS mathematics results of the six countries used and compared with South Africa in this study. The TIMSS 2011 mathematics achievement outcomes were reported as average scores and distributed on the mathematics achievement scale. The selection of these countries will be explained later in Chapter 3.

Table 2:2 Average scale scores of Grade 8/9 mathematics results

Names of countries	1995	1999	2003	2007	2011
Norway	498	#	461	469	475
Sweden	540	#	499	491	484
Saudi Arabia	418	422	411	403	415
South Africa	276	275	264	#	352
Thailand	#	467	#	441	427
Singapore	609	604	605	593	611
United Arab Emirates	#		#	#	456
# = Did not participate in the TIMSS study or data not available					

South African schools have been participating in the TIMSS international studies since 1995 as indicated in Table 2:1. However, South African schools were not part of the TIMSS 2007 study and as such no results are available (Mullis, Martin, & Foy, 2008). Furthermore, it has been found that the South African learners are underachieving when compared to their international counterparts in mathematics, since the inception of these comparative studies (Mullis, Martin, Foy, et al., 2012).

In 2011, the TIMSS results showed that South African learners had the lowest performance when compared to all countries analysed in this enquiry (Mullis, Martin, Foy, et al., 2012).

2.4.2 Southern and East African Consortium for Monitoring Quality studies

Southern and East African Consortium for Monitoring Quality (SACMEQ) studies are the cross-national initiative of Southern and Eastern African countries. This study appraised Grade 6 learners' numeracy and literacy skills in each of the participating countries. South African schools participated in the 2000 and 2007 SACMEQ studies. These SACMEQ results disclosed that there was no statistically significant improvement in mathematics and reading of Grade 6 learners in South Africa. However, there was an improvement in other African countries, such as Tanzania and Namibia.

In 2000 South Africa had a lower score for mathematics than lower-income countries such as Botswana, Swaziland and Kenya (Van der Berg, 2007). The SACMEQ (2007) results also revealed that out of all countries that participated, South African learners were ranked 8th for mathematics behind countries with the lowest GDP such as Tanzania, Kenya and Swaziland.

2.5 Annual National Assessment (ANA) conducted in South Africa

The DBE implemented the Annual National Assessment (ANA) system in 2011 focussing on mathematics and literacy. The ANA evaluation system is a segment of learner attainment as laid down in Section 6A (2) of the South African Schools Act, 1996 (Act No. 84 of 1996) that is compulsory for all government and state funded independent schools. The ANA assessment system is grounded on the National Curriculum Statement (NCS) and is aimed at testing learner's competency as required by the curriculum. Furthermore, the DoE (2011) indicated that this standardised examination verifies that every learner in all the South African government schools is acquiring the language and mathematics skills suitable for the grade. It is evident that the main purpose of the ANA is to track Grade 1 to 9 learners' performance in language and mathematics with the aim of diagnosing areas of weakness. The Action Plan to 2014: Towards the Realization of Schooling 2015, provides targets for improving learning outcomes in the South African Education sector (DBE, 2011). Figure 2:1 shows the distribution of the ANA national average marks of Grade 9 mathematics learners from 2012 to 2014.

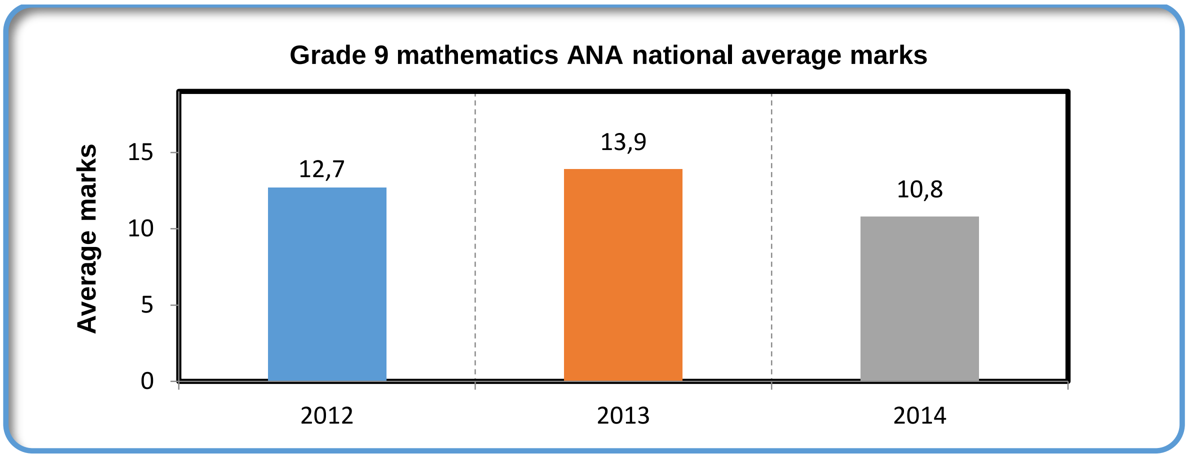

Figure 2:1 Grade 9 Annual National Assessment national average marks

It is clear that the national average marks of learners' achievements have not surpassed the 14% level. It should be noted that ANA data is not used in this study but stated to the reader in order to note the different types of assessments that are conducted in South Africa, focusing on mathematics.

2.6 Mathematics strategy in South Africa

It is indeed based on the reports released by the DoE that the number of learners passing mathematics at Grade 12 level in South Africa has not increased as expected (Department of Basic Education, 2013). This is evident from the results released annually by the DoE where there is a decline in the number of learners passing mathematics in Grade 12. It is in this regard that in 2001 the DoE developed and released the Mathematics, Science and Technology Education (MST) Strategy (DoE, 2001; 2004).

The main objective of the MST strategy was to address poor output of mathematics, science and technology learners in Grade 12 (DoE, 2004). This strategy was also aimed at maximising learning and improving learner performance in mathematics and science from Grade 1 to 12. The strategy was known as the Dinaledi schools initiative, and was aimed at increasing and enhancing learner understanding of mathematics, physical sciences and technology (O'Connell, 2009). Furthermore, the Dinaledi schools initiative was meant to increase the number of learners taking mathematics and science in Grade 12. A total of 500 schools were identified nationally in the pilot phase.

In an effort to curb the dwindling number of learners enrolling for mathematics in Grade 12, the Department of Education introduced mathematical literacy as an additional subject (DoE, 2006). This policy document asserts that "contexts are central to the development of mathematical literacy, by its very nature, requires that the subject be rooted in the levels of the learners" (DoE, 2003, p. 42). Statistics released annually during the announcement of Grade 12 results have indicated a slight increase in a number of learners passing the Senior Certificate due to this intervention. Borrowing from various authors, the results of the analysis of learners' achievements and teachers' classroom teaching indicate that "teachers are crucial to students' opportunities to learn mathematics, and substantial differences in the mathematics achievement of students are attributable to differences among teachers" (Ball et al., 2008, p. 7).

2.7 Integration of technology into the classroom

The integration of ICT into mathematics teaching has turned out to be a basic requirement in the majority of mathematics curriculum standards around the world. For instance, taking a cursory look into some of the countries worldwide, the Chinese Standards for Senior High School Mathematics Curriculum call for "paying attention to integrating information technology into mathematics curriculum" (Ministry of Education, 2003, p. 5). Furthermore, the United States Principles and Standards for School Mathematics indicated that "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (National Council of Teachers of Mathematics, 2000, p. 24).

There is also a need for teachers to develop their technological skills in order to integrate technology in mathematics classrooms (Mishra & Koehler, 2006). It is therefore imperative for teachers to have the requisite knowledge regarding technology, content and instruction. Furthermore, teachers are required to possess technological, pedagogical and content knowledge to be able to teach learners mathematical principles and concepts in a technology-enabled environment. Notwithstanding the magnitude of the emerging technologies for classroom instructions, it seems as if only a small number of teachers have the know-how to use technology in the classroom. Therefore, integrating information technology into mathematics classrooms has turned out to be the most important prerequisite in the majority of the mathematics curriculum standards all over the world (NCTM, 2000, DoE, 2003, 2004).

2.7.1 Digital literacies

Various authors concur that the world is shifting towards "digital learning" (Bull & Hammond, 2008; Rogers, 1995; Weller, 2002). There is consensus among these researchers that technological advancement has transformed the manner in which teaching and learning is taking place. Gillen and Barton (2010) argued about the dynamic nature of digital literacies. Furthermore, Beetham, McGill, and Liitlejohn (2009, p. 22) deduced that "we are living in a technology-rich societies and need to remodel education as a lifelong learning". This is due to the fact that technology is developing at a very fast pace. These authors defined digital literacies as "the constantly changing practices through which people make traceable meaning using digital technologies" (Gillen & Barton, 2010, p. 9).

Beetham and Sharpe (2007) stated that if the purpose of education is the development of digital literacies, then it is imperative to understand pedagogical practices. Furthermore, Attwel and Hughes (2010) stated that there has been a huge interest in pedagogical theories and procedures for the integration of technological tools as part classroom practices. The integration of technology into instruction has been part of education for a number of years, however it is still deemed relatively new to integrate technology into the curricula (Gulbahar, 2007).

2.7.2 Evolution of technology

Technology will continue to evolve and help education to become more flexible and adaptable in digital-based resources. This notion is supported by Ellis and

Goodyear (2010, p. 104) who indicated that "when teachers do not focus on the development of student understanding and have poor conceptions of learning technologies, they tend to use e-learning as a way of delivering information and bolting it on to course design in an unreflective way".

It has been pointed out that digital technology has the potential of assisting learners to become “engaged thinkers, global citizens and active learning participants in collaborative social learning environments” (Alberta Education, 2011). Therefore, in order to access high-order thinking amongst learners it is imperative that there is an alignment between learning activities and technologies (Abel, 2007). Furthermore, it has been pointed out that "it is not the technology that is more important but the activity that it enables: the activity, not the technology, is what advances learning" (Oblinger & Oblinger, 2005, p. 74). Teachers need to understand the pedagogy in the new curriculum and use technology as a tool, to design a learning experience that reaches more students.

Teachers are required to understand new pedagogical approaches and curriculum redesign in order to benefit from the new technology (Hedberg & Stevenson, 2013). The understanding of the pedagogy will help teachers design activities that incorporate technology as a tool to meet the need of their learners. Furthermore, teachers are required to learn and master how to use technological tools in order to engage students in their learning. It is important that teachers understand the intended purpose of integrating classroom technologies to ensure the alignment between aims, activities and the type of technologies that is at their disposal. Based on the literature it is clear that technology is a bridge that connects theory and practice (Rahimi, Beer, & Sewchurran, 2012; Robin, 2008). Technologies bring new levels of authenticity and collaboration to the learning experience (Gosper & Ifenthaler, 2013). For example, the manipulation of simulations in a lesson can assist students to understand abstract concepts (Robin, 2008). Technology is a tool that enables teachers to present activities to learners that was not possible inside a traditional classroom using traditional learning tools (DoE, 2004).

2.7.3 South Africa’s Policy on e-Education

In 2004 the DoE in South Africa published the White Paper on e-Education which spelled out that “information and communication technologies (ICTs) have the potential to improve the quality of education and training” (DoE, 2004, p. 9). The policy goal of the White Paper on e-Education was that “every South African manager, administrator, teacher and learner in general and further education and training will be ICT capable by 2013” (DoE, 2004, p. 17). The White Paper on e-Education indicates that there are disparities between those who have access to these new technologies and those without access, the so called “digital divide” (DoE, 2004). Furthermore, it specified the commitment of government to ensure that all learners gain access to ICTs in order to lessen the threats of an entrenched digital divide in future. The policy on e-Education (DoE, 2004) talks about “e-Education” as an instrument that brings about remarkable challenges with regard to teaching and learning with digital technologies.

The policy highlights the importance of ICTs as more than developing computer literacy. The policy emphasises that every learner in the Basic Education Sector should be ICT proficient by 2013 (DoE, 2004). However, the policy made this huge pronouncement, but has failed to come up with implementation strategies that were aimed at driving this mandate. As such, this goal has not yet been attained due to lack of funding and competing priorities in various provinces. Some of the Provincial Departments such as Gauteng and Western Cape have leapfrogged and provided schools with technologies, through projects such as Gauteng Online, Gauteng Paperless Classroom and the Khanya Project, costing the country millions of rand. The primary goal of the Khanya and Gauteng Online projects was to use ICTs in teaching and learning (DoE, 2004). The schools were provided with computer laboratories and educational software. Furthermore, teachers and schools’ managers were trained on how to infuse technology into the curriculum (DoE, 2004).

However, the remaining provinces, namely Eastern Cape, Free State, KwaZulu Natal, Limpopo, Mpumalanga, Northern Cape and North West are still lagging behind in terms of the implementation of ICTs into teaching and learning (DoE, 2004). Technological advancement has brought a new way of thinking about teaching and learning to South Africa.

2.7.3.1 ICT Professional Development

Procuring computers that are connected to the Internet and installed with appropriate educational software does not automatically suggest that technology will be integrated into teaching and learning. Despite the availability of the ICT policy in South Africa, the majority of educators have not been trained properly during their pre-service education to integrate technology as part of their classroom practices. Based on the current situation at school level, many teachers lack sufficient information and communication technology knowledge to work on their own, to surf the web and gain valuable information (DoE, 2004).

2.7.3.2 Teaching and learning materials

The e-Education policy articulates that South African schools need learning and teaching support material that are easily adaptable and accessible from various platforms (online and offline) using a variety of devices (DoE, 2004). Currently, the basic education sector has under-developed multimedia resources for teaching and learning. The development and provisioning of interactive digital resources is one of the critical factors relating to the integration of ICT in teaching and learning (DoE, 2004). It is therefore, imperative for the basic education sector that if ICTs are to be used in teaching and learning, adequate interactive digital resources should be made available to support the specific and overarching goals of the curriculum.

2.8 Teachers' beliefs

TIMSS studies mainly focus on academic performance of learners, but they also include questions that address the self-reported beliefs of teachers. As such, it was important to explore the topic that examines teachers' self-reported beliefs in this study. Various authors stated that regardless of the prevalence of studies interested in beliefs, there is still a widespread discussion regarding the definition and attributes of beliefs (Furinghetti & Pehkonen, 2002; Kagan, 1992; Pajares, 1992). The appraisal of research on the subject shows that beliefs are a disorganised concept that has caused confusion in education (Furinghetti & Pehkonen, 2002; Kagan, 1992; Pajares, 1992). The confusion is attributed to the distinction between belief and knowledge (Pajares, 1992). This pronouncement was first articulated by Nespor (1987), namely that the distinction between these two concepts is that knowledge seldom changes, while beliefs do.

There is a myriad of concepts related to beliefs, as some researchers consider beliefs to be part of knowledge, attitudes and conceptions (Pajares, 1992; Thompson, 1992). Furthermore, McLeod (1992) indicates that these differences can also be articulated to various disciplines, for example, in psychology emotions can have different meaning than in other disciplines. In addition, it is possible that researchers might use similar terminology although looking at different phenomena. Likewise, beliefs are somehow understood to have episodic characteristics and are associated with individual experiences (Nespor, 1987).

It has been argued that personal experiences, societal issues, individual reflection as well as responses from others' beliefs, are the main catalysts that has some bearing on an individual's belief system (Schlöglmann & Kepler, 2006). So, beliefs can be regarded as factors that are responsible for shaping a teacher's decisions. The factors mentioned above, encompass the goals that should be accomplished, and the manner in which effective learning of mathematics is perceived (Schoenfeld, 1998). Powell (1992) believed that a lot of teachers start their teaching careers with earlier fabricated and preconceived subconscious philosophies in relation to teaching.

2.8.1 Beliefs about mathematics

Researchers argued that beliefs are the most valuable psychological concept that should inform teacher education (Grossman, 1990; Holt-Reynolds, 1992). More recently, Lepik and Pipere (2011) indicated that the most popular research topic is about teachers' beliefs related to mathematics didactics. It is evident that there is a worldwide interest from researchers, communities, and policymakers, in understanding various avenues in which teachers beliefs have contributed and influenced students' academic achievement. Nonetheless, various researchers pointed out that only a few comparative studies have been conducted across countries that looked at teachers' beliefs (Andrew & Hatch, 2000; Felbrich, Kaiser, & Schmotz, 2012; Pepin, 1999).

It is apparent from the conclusions drawn in teachers' perceptions and interrelated areas of research in education, that teaching procedures are influenced by innumerable factors (Borko & Putnam, 1996; Clark & Peterson, 1986). These factors, which influence teaching practice, include amongst others, pedagogical knowledge, teachers' subject matter knowledge and pedagogical content knowledge. Researchers advocate that beliefs are the most important force that has an effect on teaching and learning (Calderhead, 1996; Pajares, 1992; Thompson, 1992). Several researchers have classified beliefs about mathematics into three fundamental elements as indicated in Table 2:3.

Table 2:3 Fundamental concepts about mathematics beliefs

Author(s) and year	**Fundamental categories**		
	The instrumentalist	**Platonist**	**Problem solving**
Ernest (1991)	Mathematics is perceived as a set of unrelated but useful rules and facts.	Mathematics is seen as a unified body of knowledge that is discovered rather than being created.	Mathematics is seen as a dynamic and continually expanding field of human creation and invention.
	Toolbox aspect	**System aspect**	**Process aspect**
Törner & Grigutsch (1994)	Mathematics is regarded as a set of procedures, formulae and expertise.	Mathematics is seen as a process that is symbolised by rigorous evidence, logic as well as specific mathematical linguistic.	Mathematics is viewed as a constructive practice, mathematical pursuit comprises of creative stages.

The focal point of research pertaining to beliefs in mathematics education, is the teachers' viewpoints about the attributes assigned to mathematics, its teaching and learning, and teaching in general (Ernest, 1991; Liljedahl, Rolka, & Rosken, 2007). The implementation of teachers' beliefs into practice is influenced by the context in each country based on the pedagogical practices, school culture and the background of the learners (Lepik & Pipere, 2011). Moreover, knowledge of teacher beliefs in the field of assessment may inform pre-service and in-service teacher education or curricular reforms (Brown, 2004).

There are also some inconsistencies with regards to some of the researchers who consider mathematics as problem solving (Cooney, 1985), while a contrary view was espoused by Schoenfeld (1985) that mathematics is not problem solving. In conclusion, the scholarly articles published on teachers' beliefs about mathematics indicate that mathematics is associated with the knowledge of using correct procedures, as well as formulas (White, Way, Perry, & Southwell, 2005).

2.8.2 Changing teachers' beliefs

Scholars posit that teachers' beliefs have an effect on the manner in which a teacher chooses what to teach and how to conduct a lesson (Grossman, 1990; Pajares, 1992; Shulman, 1987). Therefore, any investigation of teachers' beliefs has a prospect of achieving remarkable and profound understanding into a number of aspects that relate to a teacher's professional career.

For example Nespor (1987, p. 321) spells out that

> *"belief systems often include affective feelings and evaluations, vivid memories of personal experiences, and assumptions about the existence of entities and alternative worlds, all of which are simply not open to outside evaluation or critical examination".*

That said, changing teachers' beliefs about classroom instruction is a complicated and challenging undertaking. The most frequent conclusion in the literature is that changing teachers' beliefs is a complicated and mysterious process (Handal, 2003; Prawat, 1992). Woods (1996) indicated that it is not easy to change teachers' beliefs when they are firmly intertwined with other beliefs. Woods (1996, p. 293), argues that this course of action can "lead to periods of disorientation, frustration, even pain".

Researchers have argued that in order to implement instructional change in education. it is imperative to slowly modify teachers' preconceived practices and beliefs by interchanging them with appropriate ones that are modelled by experiences (Dwyer, Ringstaff, & Sandholtz, 1991; Nespor, 1987)**.** Dwyer et al. (1991, p. 51), discovered that "teachers' beliefs may be best modified while they are in the thick of change, taking risks and facing uncertainty". Therefore, it can be argued that the moment teachers are faced with transformation, they are compelled to re-examine their beliefs related to classroom instruction and thus instructional change takes place.

Furthermore, as Clark (1988) suggested, teachers hold on to implicit theories and idiosyncratic views throughout their teaching professions. These beliefs affect "perception, interpretation, and judgment and impact the judgments and actions teachers make every day" (Clark, 1988, p. 7). That said, it is important to note that understanding teachers' verdicts entails having an insight into how they choose what knowledge to invoke, when, and how. The choices that teachers utilise indicate the manifestations of their tacit believe that are seen as imperative and plausible (Speer, 2005). Teachers' beliefs signify the way in which teaching and learning are conceptualised (Stipek, Givvin, Salmon, & MacGyvers, 2001). In addition, teachers' beliefs symbolise a multifaceted and interconnected structure of individual as well as specialised knowledge (Cross, 2009). Teachers' beliefs serve as implicit principles and mental diagrams for experiencing and responding to reality (Borko & Putnam, 1996). It can be concluded that beliefs depend on intellectual and affective elements which are often unspoken (Borko & Putnam, 1996; Cross, 2009).

2.8.3 Beliefs about classroom practice

There are a number of studies that classified differences in teachers' beliefs as being constructivists or behaviourists (transmissionists) (Lepik & Pipere, 2011; Mansour, 2009). In the study that investigated pre-service teachers' learning and knowledge beliefs, Klien (1996) argued that teachers' beliefs can be opposite and eclectic. This author pointed out that teachers may possess both behaviourist as well as constructivist philosophies based on the setting that these beliefs may reflect. In addition, Klien (1996, p. 370) explained that beliefs "are not organized into a coherent body of knowledge". According to Yılmaz and Şahin (2011, p. 84) this notion is supported by (Collinson, 1996, p. 10) who also found contradictory beliefs regarding teaching practices which "produced tensions between adherents of behaviorist and constructivist paradigms".

According to Calderhead (1996), appraisal of the literature on teachers' beliefs and knowledge argues that teaching is perceived by some teachers as an endeavour whereby knowledge is transmitted, while other teachers view it as a process of providing guidance to the learners when they are engaged in a learning process. It has been argued by Taylor (1990) that teachers need to change their belief system in order to develop new practices, thus accommodating constructive epistemology.

2.8.4 Beliefs about using technology into the classroom

Several exploratory studies have been carried out to determine teachers' thinking that is associated with the manner in which they accept, or fail to utilise, technology as part of their classroom practices (Hannafin & Freeman, 1995; Honey & Moeller, 1990; Olech, 1997). The outcomes of these studies discovered that expert educators held more objectivist views on learning as compared to pre-service teachers. Olech (1997) argued that if teachers' behaviourist conducts are rooted in their pedagogical orientation, it is less likely that they would use a computer instructionally.

Several suggestions were made about how teachers should be supported in order to integrate technology into teaching and learning (Ernest, 1991; Honey & Moeller, 1990). The recommendations made, proposes that changes may be required, not only in teachers' beliefs but in the educational system itself "for teachers whose educational beliefs and practices are traditional, there exist different and much more complicated barriers for technology integration" (Honey & Moeller, 1990, p. 16). Furthermore, Becker (1991, p. 6) argued that teaching practices are the outcomes based on teachers' "own schooling, training and experience as teachers". Becker (1991, p. 8) indicated that teachers' teaching techniques are shaped by their beliefs and also influenced by "the regularities in the social structure in which most of them work".

The introduction of computers into teaching and learning is believed to have a bearing on the role of a teachers as well as shifting their beliefs from a didactic to a constructivist approach (Bracey, 1993). It is imperative for researchers to understand the underlying theoretical issues that underpins teachers beliefs about the integration of technology into teaching and learning (Hannafin & Savenye, 1993). Hannafin and Savenye (1993) provided a list of research-based reasons about why teachers resist using micro-computers. These reasons encompass the following issues:

(a) Teachers are frustrated in learning how to use the computer and this is the main reason that makes some of them quit early;
(b) The software that teachers are required to use in teaching and learning is poorly-designed;
(c) Integrating computers into classroom instruction calls for more investment in time and determination; and
(d) Teachers are terrified of giving away authority in the classroom because of their inadequate computer skills.

2.9 Diffusion of Innovation Theory

A number of theories have been used to determine the acceptance and uptake of innovations. The most prevalent of these theories is the Diffusion of Innovation (DoI) theory that describes the adoption of technology (Rogers, 1995). The DoI theory is aimed at clarifying how, why and at what rate ideas are implemented in the social system (Rogers, 1995). Based on the DoI theory, there are four fundamental components that are regarded as the drivers on new ideas namely, (a) innovation, (b) communication channel, (c) time and (d) social system (Rogers, 1995). To be able to understand the DoI theory, it is imperative to examine the concepts on which it is formulated.

2.9.1 Innovation

Rogers (1995, p. 11) describes innovation as an idea, behaviour or a physical object perceived by a human being or an adoption unit as being the latest. It has been postulated by innovation theorists that there are key features that determine the speed at which a new idea is adopted (Rogers, 1995; Van Braak & Tearle, 2007). These key features include relative advantage, compatibility, complexity, trialability and observability (Rogers, 1995). Relative advantage is the extent to which a new innovation is viewed as being more advanced than the innovation it supersedes. Compatibility is regarded as a way that an innovation is designed to accomplish the needs as ascertained by potential adopters (Chen, Gillenson, & Sherrell, 2004). Research suggests that when an innovation is perceived as having more benefits or compatibility with the envisaged user, then it is likely to be adopted (Au & Kauffman, 2008; Ondrus & Pigneur, 2006). Complexity is the extent to which a potential adopter views an innovation as being complex and not easy to implement (Cheung, Chang, & Lai, 2000). Trialability is the degree to which a potential adopter is afforded an opportunity to experiment with and understand the innovation using a phased-in technique (Agarwal & Prasad, 1998). Indeed, technological innovation more often than not possesses some degree of benefit for its potential adopters. These envisioned adopters are "seldom certain that an innovation represents a superior alternative to the previous practice that it might replace" (Rogers, 1995, p. 13). Lastly, observability refers to the extent to which members of a social organisation can embrace an innovation if it produces visible results (Rogers, 1995).

2.9.2 Time taken for the adoption of innovation

According to Rogers (1995), time taken for adoption is defined as a speed at which individuals in a social system embrace innovation. The adoption and diffusion of an innovation takes place over a period of time and is influenced by members of the social group. Early adopters require a shorter adoption time when compared to late adopters. Rogers (1995) indicated that the initial stage of diffusion of an innovation is very slow, then it accelerates and reaches a period of dynamic and rapid growth then it stabilises and eventually declines. Therefore, innovations are disseminated within a social system over a period of time in a pattern that is similar to an s-shaped curve (Rogers, 1995).

2.9.3 Communication channels

A communication channel refers to the manner through which messages about an idea are communicated to the members of the social system (Rogers, 1995). Information that is relevant to the innovation should be broadcast in order to influence decisions between members of the social system (Rogers, 1995). Mass media, information technologies and face-to-face channels are all those means that are used to convey information between two or more individuals in a social system.

2.9.4 Social System

A social system is defined as “a set of interrelated units that are engaged in joint problem solving to accomplish a common goal” (Rogers, 1995, p. 23). A social system represents a boundary within which an innovation proliferates. Important concepts within the social system are the structure, system norms, opinion leadership and change agents (Rogers, 1995). The theory indicates that members of a social system who are regarded as being innovative will embrace a new idea before those who are less predisposed (Surry & Farquhar, 1997). In a social system decisions are taken to ensure that the innovation is implemented successfully. There are three types of innovation-decisions that exist within a social system, namely optional, collective and authority (Rogers, 1995). These decisions are either made voluntarily or there are individuals within the organisation that reach these verdicts. As a result, the adopters’ classifications are based on their innovativeness.

(a) Adopter categories

Adopter groups are viewed as a classification of human being within a “social system on the basis of innovativeness” (Rogers, 2003, p. 22). Innovativeness is described as the “degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system” (Rogers, 2003, p. 22). Furthermore, Braak (2001, p. 144) referred to innovativeness as “a relatively-stable, socially-constructed, innovation-dependent characteristic that indicates an individual’s willingness to change his or her familiar practices”.

The aforesaid classification structure consists of *innovators*, *early adopters*, *early majority*, *late majority* and *laggards*. On one extreme of the distribution are the innovators and on the other end are the laggards (Surry & Farquhar, 1997). Figure 2:2 indicates the normal distribution of individual innovativeness and the percentage of probable adopters (Rogers, 1995). It is clear from Figure 2:2 that the distribution of adopters is a normal curve and is achieved over time after an innovation has been successfully implemented (Rogers, 1995).

Figure 2:2 Adopter groups (Adapted from Diffusion on Innovation, Rogers (1995))

i. <u>Innovators</u>

According to Rogers (2003), innovators are members of a social system who are eager to experience and embrace new thoughts. Furthermore, innovators are regarded as adventurous individuals who adore being at the cutting edge of innovation.

ii. <u>Early adopters</u>

Early adopters as members of a social system are likely to hold leadership roles (Rogers, 2003). As such early adopters provide guidance to other members of the social system about an innovation. In fact, being leaders they “play a central role at virtually every stage of the innovation process, from initiation to implementation, particularly in deploying the resources that carry innovation forward” (Light, 1998, p. 19). Early adopters are role models in the perceived social system, their attitudes toward any innovations are more imperative. Therefore, early adopters’ leadership in encompassing new ideas reduces doubts within the social system regarding the diffusion process of an innovation.

iii. <u>Early majority</u>

Rogers (2003) claimed that the early majority are individuals who do not possess the leadership role. However, their interpersonal networks are still valuable in the innovation diffusion process. As such they are deliberate in adopting an innovation and they are neither the first nor the last to adopt it (Rogers, 2003). Thus, their acceptance of new invention usually requires more time as compared to early adopters.

iv. Late majority

Late majority constitutes one-third of the individuals within the social system who are doubtful about the innovation and its results. This group normally stay behind until the majority of their colleagues have adopted an innovation. However, peer pressure may lead them to the acceptance of the new ideas. Rogers (1995) attest to the fact that in order to reduce the uncertainty of the innovation, interpersonal networks of close friends should encourage the late majority to accept new innovation (Rogers, 2003, p. 284).

v. Laggards

Laggards are individuals who possess traditional values and they are more uncertain about the latest innovations (Rogers, 2003). This group of individuals are usually isolated from the social system and as such, their interaction decreases their awareness of innovation benefits. Therefore, laggards want to make sure that an innovation has been implemented and has been working properly in the past before adoption. It is based on these attributes that their decision making process is to a certain extent very lengthy.

2.10 Challenges with technology integration

The outmost challenge in education is for teachers to leverage on the affordances of digital tools in their classroom. Watson (2006) indicated that computer technology persists to develop at an unprecedented speed in all aspects of our society. As such national and worldwide statistics reveal that educational institutions are continuously being provided with technological devices (Bauer & Kenton, 2005; Pelgrum, 1992) and access to the Internet (Cattagni & Westat, 2001). Despite widespread access and possible learning benefits, research suggests that the potential of computer technology has not being realised because of the under-utilisation of computers in many schools (Abrami, 2001; Muir-Herzig, 2004). The under-utilisations of computers have been noticeable for some time and still continue to be an international issue.

The considerable amount of capital investment in “educational” ICTs, which commenced during the late 1970s, has continued to increase even to date (Haydn & Barton, 2007; Twining, 2002). However, regardless of this investment in education the return on investment of ICT on teaching and learning still looks patchy (Twining et al., 2006). However, learning is influenced by the technological world in which learners find themselves (Iding, Crosby, & Speitel, 2002). Educational environment on the other hand is still rooted in the traditional way of teaching and learning where much of the material is still in print and media ((Iding et al., 2002).

2.11 Mechanism of technology adoption

In essence, diffusion comprised of complicated, non-linear, interrelated concepts and systems that attempt to describe the process of change (Rogers, 1995). The process of change is based on decisions that occur in a community. According to Rogers (1995), diffusion of innovation takes place over time and comprises of five distinct stages namely, knowledge, persuasion, decision, implementation and confirmation. The adoption process requires a potential adopter to learn about innovation and accept or discard it after engaging. Furthermore, this process requires an individual to put an innovation into use and appraise its outcomes based on the innovation decision process that has been made. However, in some instances many innovation decisions are put together by an organisation rather than by individuals. In those cases, the decision making process is more complex since more people in an organisation are implicated.

New terms have evolved to specify the use of computers in education, such as Web-based learning, electronic learning, multimedia learning, mobile learning and ubiquitous learning (Voogt & Knezek, 2008). The ubiquitous learning is the current phrase that is emerging signifying the use of computers in teaching and learning. The notion of ubiquitous learning is attained from “ubiquitous computing”, which means the availability of computer technology in any location (Voogt & Knezek, 2008). Therefore, ubiquitous learning signifies the potential of computer technology that can make learning possible anytime, anywhere and anyhow.

2.12 Theoretical Framework

Many researchers, including, Koehler and Mishra (2005) advocate that one novel way to learn about the complexities of teaching with technology is to engage in the design process. It is further explained that

> *"through the design process, learners must constantly work at the nexus of content (what to teach), pedagogy (how to teach it), and technology (using what tools)" (Koehler, Mishra, Bouck, DeSchryver, & Kereluik, 2011, p. 151).*

It is in this context that the TPACK theoretical framework is examined to inform the conceptual framework used for this study. This framework has been selected to provide readers of this study with the ability to understand the synergies of bringing together technology, content and pedagogy (Mishra & Koehler, 2006). TPACK theoretical framework provides overwhelming information to teachers about various issues that should be taken into cognisance in order to integrate technology into teaching and learning.

The most critical element pertaining to technology is that it should not drive teaching and learning (Jonassen, 2000). Jonassen (2000) argued that instruction should determine the nature of the technological tools to be used in the classroom. Furthermore, Harris and Sullivan (2000, p. 1) conceded that,

> *"the tremendous technology potential will only be realized if we can create a new vision of how technology will change the way we define teaching and how we believe learning can take place".*

In addition, it has been argued that technology alone cannot bring about the envisaged change in classroom instruction unless educators are able to appraise and incorporate technology into the curriculum (Geisert & Futrell, 2000).

2.12.1 The TPACK framework for teacher development

Several authors (Grossman, 1990; Koehler & Mishra, 2005; Pierson, 2001; Shulman, 1986) have discussed the evolution of PCK to TPACK in teaching and learning. The order of events of these papers from 1986 to 2008 is used to analyse in what manner this concept has advanced all the way through. Furthermore, it should be noted that only peer evaluated articles accessible in academic journals were analysed.

Figure 2:3 indicates the evolution of the Technological Pedagogical Content Knowledge framework by various authors since 1986 to 2008. The TPACK framework is used in this research.

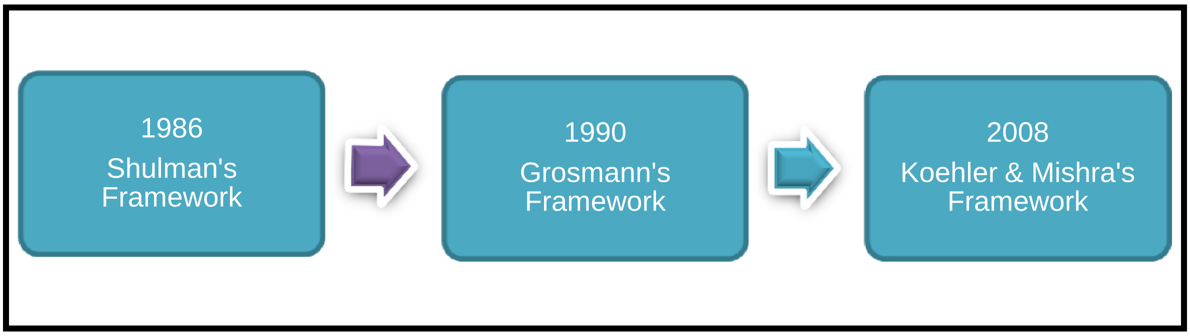

Figure 2:3 Development of TPACK framework (1986 to 2008)

2.12.2 Shulman's framework

The Pedagogical Content Knowledge (PCK) concept was developed and published by Shulman (1986, p. 9) as a tool that can used by teachers to represent and formulate concepts, teaching and learning techniques as well as epistemological assumptions. The essential principles of this concept are the two knowledge forms, namely pedagogy and content. This model is defined as an intersection between pedagogy and content knowledge, which a teacher should have in order to produce an efficient outcome. Furthermore this author (Shulman, 1986, p. 9) indicates that content knowledge can be categorised into three distinct groups, namely (a) subject matter content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge.

2.12.3 Grossmann's framework

Grossman (1990) extended the PCK framework by defining a pedagogical model based on general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge, and knowledge of context. This author indicated that PCK is a vital component that teachers require in their professional knowledge.

2.12.4 Koehler and Mishra framework

The Shulman's concept of PCK was utilised and extended to the TPACK framework whereby teachers are integrating technology into their classroom practices (Mishra & Koehler, 2006). These scholars indicated that it is critical for teachers to be familiar with how the three forms of knowledge (content, technology and pedagogy) supports and constrains each other.

In the TPACK framework, the intersection of the three "core" knowledge components is TPACK, which can be seen as an extension from PCK. Considering the importance of PCK and the widely use of technology in classroom teaching, TPACK seems to be more and more important. It is regarded as "the basis of effective teaching with technology" (Koehler & Mishra, 2009, p. 66). Furthermore, based on the development of technology, TPCK was introduced as a conceptual framework to explain the type of knowledge that teachers should possess in order to teach effectively with digital technologies (Mishra & Koehler, 2006). Figure 2:4 represents the TPACK framework as suggested by Koehler and Mishra (2008).

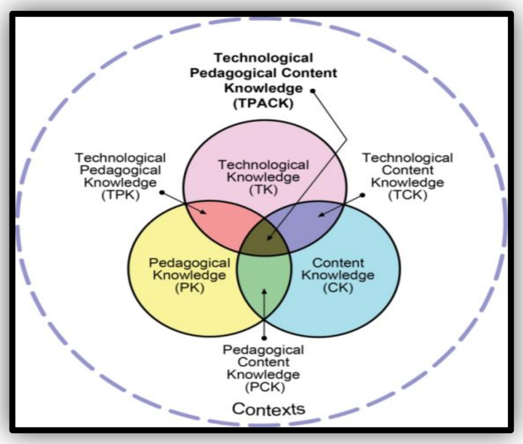

Figure 2:4 TPACK framework as suggested by Koehler and Mishra (2009, p. 63)

Figure 2:4 shows the interactions between and among the three primary forms of knowledge: pedagogy, content and technology. It can be deduced that there are two types of knowledge, namely primary and secondary forms of knowledge. These knowledge forms are explained in the subsequent paragraphs.

a) Primary forms of knowledge

It was confirmed by Mishra and Koehler (2006) that technological knowledge, pedagogical knowledge as well as content knowledge are at the heart of the TPACK framework. These three forms of knowledge are regarded as imperative in mathematics teaching due to the complexity of mathematics content, how mathematics is being taught and related instructional tools. In this section each component of the TPACK is spelled out meticulously.

Content knowledge is regarded as the initial component of TPACK. Borrowing from Mishra and Koehler (2006, p. 5) content knowledge is the concrete subject matter presented or taught to the learners. Content knowledge is regarded as the structural knowledge that is stored in the teacher's mind while pedagogical knowledge is the instructional knowledge (Shulman, 1986). Secondly, pedagogical knowledge is regarded as the understanding of how to impart the content. It is regarded as a profound knowledge pertaining to the procedures and customs "of teaching and learning and how it encompasses (among other things) overall educational purposes, values and aims" (Mishra & Koehler, 2006, p. 6). This knowledge is deemed vital as it affords teachers with an opportunity to have knowledge about students' false beliefs as well as different facets of instruction.

Lastly, as pronounced by Koehler and Mishra (2008), the letter "T" signifies technology as the most important component of the TPACK framework. Borrowing from Koehler and Mishra (2008) it is that "Technology Knowledge (T or TK) is knowledge about standard technologies such as books and chalk and blackboard, as well as more advanced technologies such as the Internet and digital video" (p.4). These authors further suggest that teachers should have the necessary skills and knowledge in order to integrate various technologies that are available and accessible in teaching and learning.

b) Secondary forms of knowledge

The secondary forms of knowledge that are formed when the three primary forms of knowledge intertwine are proposed by Koehler and Mishra (2008) as follows:

a) Pedagogical Content Knowledge (PCK) includes knowing what teaching approaches are appropriate based on the content to be taught and knowing how various components of the content can be organised for instruction.

b) Technological Content Knowledge (TCK) is described as an approach in which technological tools are used to enrich instructional content. It is imperative for teachers to possess this type of knowledge in order to be able to decide on the appropriate technologies to deliver the desired content to learners.

c) Technological Pedagogical Knowledge (TPK) is used to help teachers to be familiar with the affordance and restrains that technology brings about on pedagogy. This type of knowledge is necessary in order to assist teachers on how to integrate technology in their lessons during the planning of their activities. It should be noted that pedagogical undertakings that supports learning such as simulations can be deliver using technology.

d) Technological Pedagogical Content Knowledge (TPACK) is the intersection of the most important categories of content, pedagogy, and technological knowledge intersecting to create the smaller group of TCK, PCK and TPK, which intersect to create TPACK. It should be noted that these connections are much more complex to articulate since they vary due to the type of content, pedagogy or technology they have at hand. This phase present immense challenges for teachers to broaden their proficiencies in order to be able to deal with all the different knowledge types.

Technologies that can be integrated into teaching and learning are accessible in two forms, namely analogous and digital technologies (Koehler, Mishra, & Cain, 2013). Technology provides many opportunities in teaching and learning although these are not without limitations (Hew & Brush, 2007). It was confirmed by Mishra and Koehler (2006) that the efficient and effective integration of technology in teaching and learning can be described as the interconnection between *technological knowledge*, *pedagogical knowledge* as well as *content knowledge* that are at the heart of the TPACK framework. When these six types of knowledge interconnect a new knowledge, namely TPACK is formed.

2.13 Development of mathematics TPACK

Based on Grossman (1990), the PCK framework that describes how mathematics teachers integrate technology into their classroom practice was developed. It should be noted that Niess (2005) adapted Grosmann's (1989, 1990) four major components of PCK. Subsequent to extension of Grosmann's (1989, 1990) component, Niess (2005) described four facets that explained TPCK development for teachers' development programmes. The four facets are described as follows,

> *(1) an overarching conception of what it means to teach a particular subject integrating technology in the learning process; (2) knowledge of instructional strategies and representations to teach a specific subject with technology; (3) knowledge of students' understandings, thinking, and learning with technology; and (4) knowledge of curriculum and curriculum materials that integrate technology (Niess, 2006, p. 197).*

A set of mathematics teacher TPACK standards and a model was created to inspire teachers to infuse technology into pre K-12 mathematics education (Niess et al., 2009). Furthermore, Niess et al. (2009) remodelled Roger's (2003) five-stage decision-making process based on the adoption or rejection of a new innovation (Figure 2:5). This scholar suggested a five stage developmental model that a teacher progresses through while learning how to infuse various technologies as part of mathematics classroom instructions.

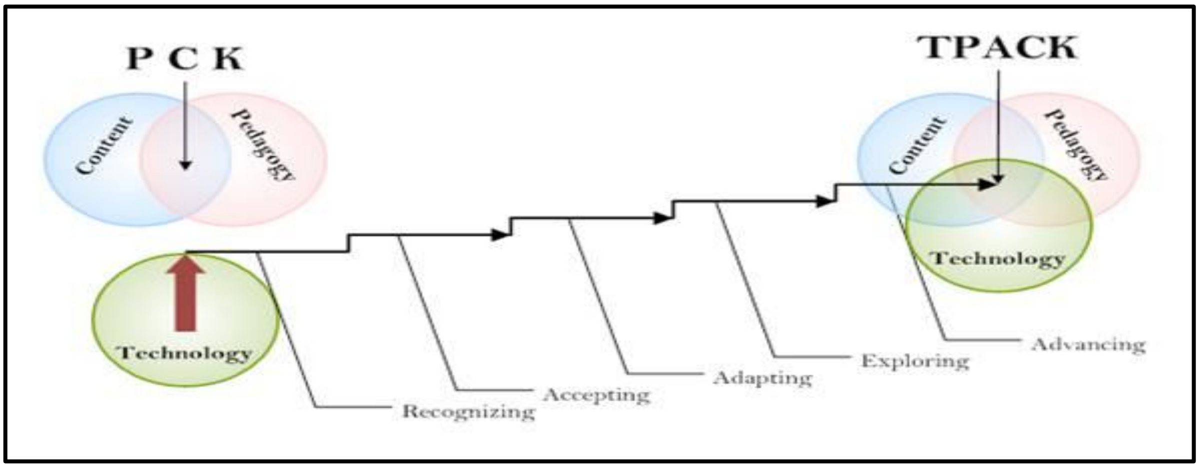

Figure 2:5 Niess, Sadri and Lee (2007) model

According to Niess, Sadri, and Lee (2007) exploration of these observations, these authors categorise teachers to be at one of the following stages:

a) ***Recognising -*** During this stage teachers are capable of using technology and recognise its alignment with mathematics content.
b) ***Accepting -*** During this stage teachers are eager to engage their learners using appropriate technology as part of the process of determining if they have a favourable or unfavourable disposition toward incorporating technology in their mathematics classrooms.
c) ***Adapting*** - During this stage teachers are able to involve their learners using appropriate technology in the instruction and learning of mathematics.
d) ***Exploring*** - During this stage teachers are actively integrating appropriate technology into the instruction and learning of mathematics.
e) ***Advancing -*** During this stage teachers are able to appraise the results of the judgement to infuse appropriate technologies into the instruction and learning of mathematics.

Indeed, these authors (Niess et al., 2007) indicated that it is imperative for mathematics teachers to infuse technology as part of their teaching and learning. Furthermore, it is evident from the literature that the subject teacher has the responsibility to ensure that technology is integrated into teaching and learning of mathematics. Teacher education researchers from various fields deeply investigated prospective and practicing teachers' knowledge, beliefs, attitudes and practices. The notion of teacher knowledge research started from Lee Shulman and his colleagues' when they combined teachers' two primary knowledge bases (Shulman, 1987). Shulman (1987), p.8 clarifies this as the "understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction". In their categories (Grossman, 1990; Shulman, 1987), PCK attracted many mathematics educators. The main reason is that PCK is regarded as core knowledge in teachers' professional knowledge. It is "the category most likely to distinguish the understanding of the content specialist from that of the pedagogue" (Shulman, 1987, p. 8). Furthermore, it is also the category most likely to distinguish the understanding of expert teachers from that of novice teachers.

2.14 Review of TPACK studies in education

The number of reviews that discussed the TPACK and asked for a methodical synthesis of both the development of TPACK as a model, and where it has been practically applied, has increased drastically over the last couple of years (Gür & Karamete, 2015). It seems that there is a need for a systemic review relating to the TPACK model. A systematic review methodology (SRm) is outlined as

> *"a specific methodology that locates existing studies, selects and evaluates contributions, analyses and synthesizes data, and reports the evidence in such a way that allows reasonably clear conclusions to be reached about what is and is not known" (Denyer & Tranfield, 2009, p. 671).*

There are three document analysis studies relating to the TPACK framework that emerged in a reviewed literature. The first group of authors, Polly, Mims, Shepherd, and Inan (2010) analysed 26 articles from 2003 to 2014, Chai, Koh, and Tsai (2013) examined 55 articles, while Gür and Karamete (2015) analysed 116 papers published between 2001 and 2014. The systematic review process used in these document analyses of the TPACK studies is described in Figure 2:6.

Phase 1: Scoping the review	Research studies conducted since 2001 in education which used the TPACK framework.
Phase 2: Comprehensive search	Make use of available electronic databases. Search criteria used: • TPACK studies • 2001 • Peer reviewed articles • Full papers
Phase 3: Quality assessment	Inclusion criteria to select papers analysis: • Studies that use TPACK framework in education • In-service mathematics teachers • Pre-service mathematics teachers • A research paper and not a discussion paper
Phase 4: Data extraction	Data extract from the TPACK studied focused on: • Author(s) • Date published • TPACK framework • Number of participants • Data analysis • Results of the study • Findings and recommendations of the study
Phase 5: Synthesis	**Discussion** of literature review: • What we know now • What we still need to know
Phase 6: Write-up	Discussion of review

Figure 2:6 Systematic reviews of TPACK studies

These researchers conducted the literature review by searching the Web of Science and the Scopus database respectively (Chai et al., 2013; Gür & Karamete, 2015). Furthermore, the Education Research Complete and Education Research Information Centre (ERIC) databases as part of EBSCOhost were also explored (Chai et al., 2013; Gür & Karamete, 2015). The “technological pedagogical content knowledge” and “TPACK or TPCK” were the keywords used in the exploration process.

2.14.1 TPACK journal articles

Figure 2:7 indicates the summary of the TPACK journal articles publications that were found between 2003 and 2014 (Chai et al., 2013; Gür & Karamete, 2015). The analysis revealed that a total of 83 TPACK articles were published between 2009 and 2010.

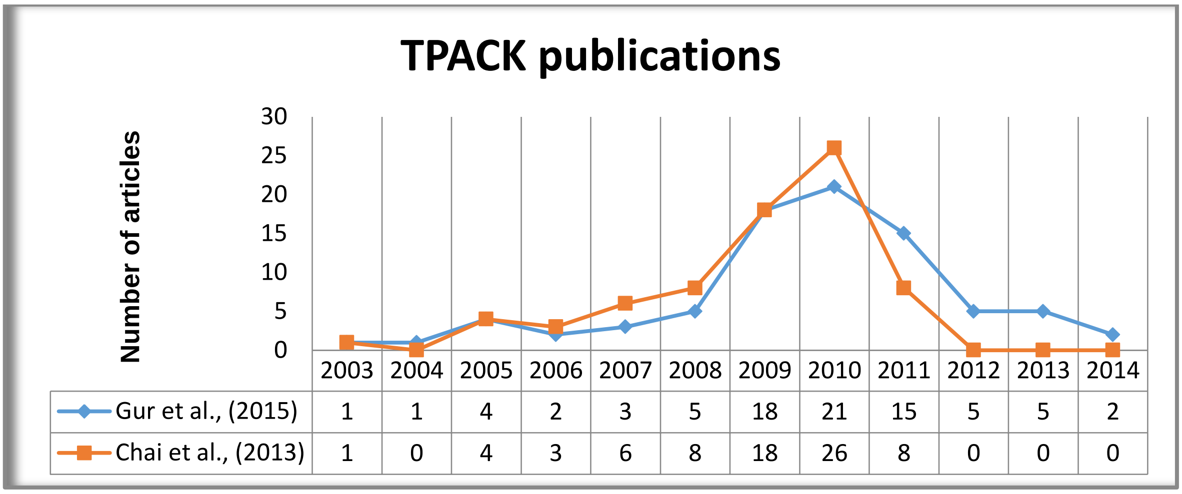

Figure 2:7 TPACK publications since 2003

Figure 2:7 shows that Chai et al. (2013) analysed a total of 74 articles in 2013 while Gür and Karamete (2015) reviewed 82 articles in 2015. There were more articles in 2010 that dealt with the application of the TPCK framework in education. Chai et al. (2013) classified the articles into two groups, namely data driven (55) and non-data driven (19) research. The data driven articles were further sub-divided into different categories as depicted in Figure 2:8.

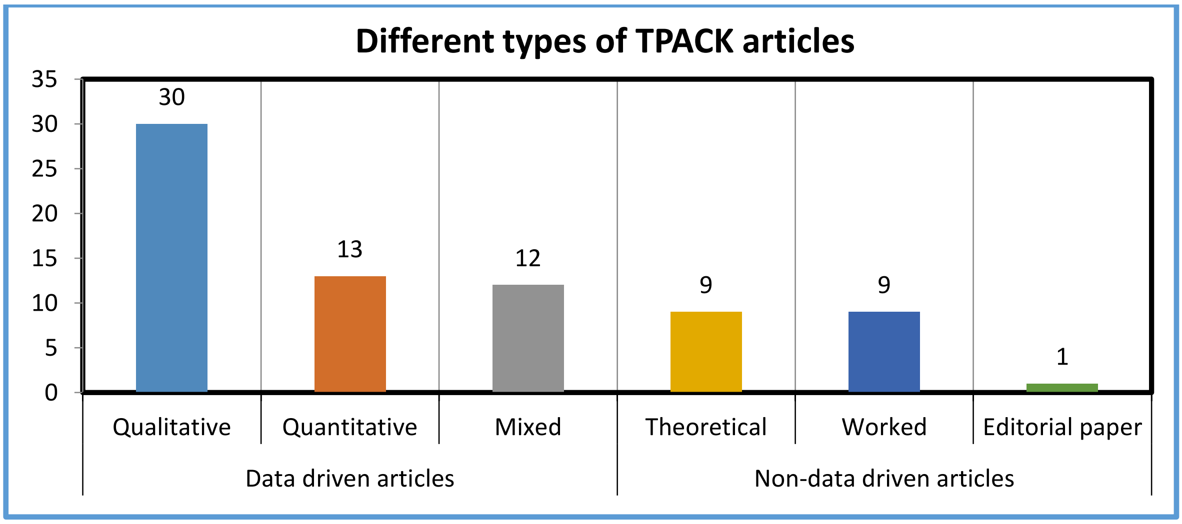

Figure 2:8 Different types of TPACK articles

2.14.2 TPACK core components

Three fundamental concepts of the TPACK framework, namely content, technology, as well as pedagogy, are typically analysed (Yigit, 2014). The subsequent paragraphs outline some of the findings related to these components.

Content analysis

It emerged that the majority of the studies (41%) were based on the science, mathematics, engineering, geography, and social studies combined with interdisciplinary studies (28%), while instructional technology contributed 31% of the distribution (Yigit, 2014). Furthermore, it can be deduced from the analysis that the integration of technology is swayed towards science and mathematics subjects.

Pedagogy used

The main theme that emerged from the analysis is that 94.4% of the papers were described as supporting constructivist-oriented pedagogy. Furthermore, the themes that emerged from the qualitative based studies that investigated learners' perception were project-based or inquiry-based learning. The analysis revealed that some of the worked examples and theoretical papers presented the constructivist as well as the behaviourist strategies (Hammond & Manfra, 2009; Harris, Mishra, & Koehler, 2009). In conclusion, the emergence of constructivist-oriented learning with technology is not astonishing due to the fact that constructivism develops a robust theoretical basis for the integration of technology into teaching and learning (Jonassen, Peck, & Wilson, 1999).

Technology employed

According to Chai et al. (2013) the technologies that were reported in the TPACK investigation were classified into two categories that emerged based on the literature review, namely subject related as well as subject specific studies. These authors stated that a total of 34 studies used subject related technologies focusing on content areas such as "web-based environments, learning management system, office tools, hypermedia authoring and interactive whiteboards (IWB)" (Chai et al., 2013, p. 44). Furthermore, twenty studies employed subject specific technologies, namely ten studies that concentrated on TCK in mathematics, and ten other studies that focused on "mathematics based technologies".

Conclusion

The theoretical papers specified that TPACK is a relevant guiding framework for teachers to acquire appropriate knowledge in order to integrate technologies into teaching and learning (Cox & Graham, 2009; Hammond & Manfra, 2009; Harris et al., 2009; Kereluik, Mishra, & Koehler, 2011; Koehler & Mishra, 2005; Koehler, Mishra, & Yahya, 2007; Pierson & Borthwick, 2010). Furthermore, the findings from the worked example papers, indicate a strong perception amongst teachers that there is a need to share educational resources and best practices related to the integration technology (Bull, Hammond, & Ferster, 2008; Toth, 2009) as well as a need for further investigation related to ICT integration (Bull et al., 2008).

2.15 TPACK framework for pre-service mathematics teachers

An additional systematic review was conducted on the development of the TPACK for Pre-service Mathematics Teachers (PSMTs) based on scholarly reviewed journal editorials published between 2005 and 2012 (Yigit, 2014). It should be taken into consideration that the fundamental principle of the review was based on the basis that this framework has been in development since 2005. The review was conducted using three scientific databases, JSTOR-Scholarly Journal Archive, PsychINFO and ERIC.

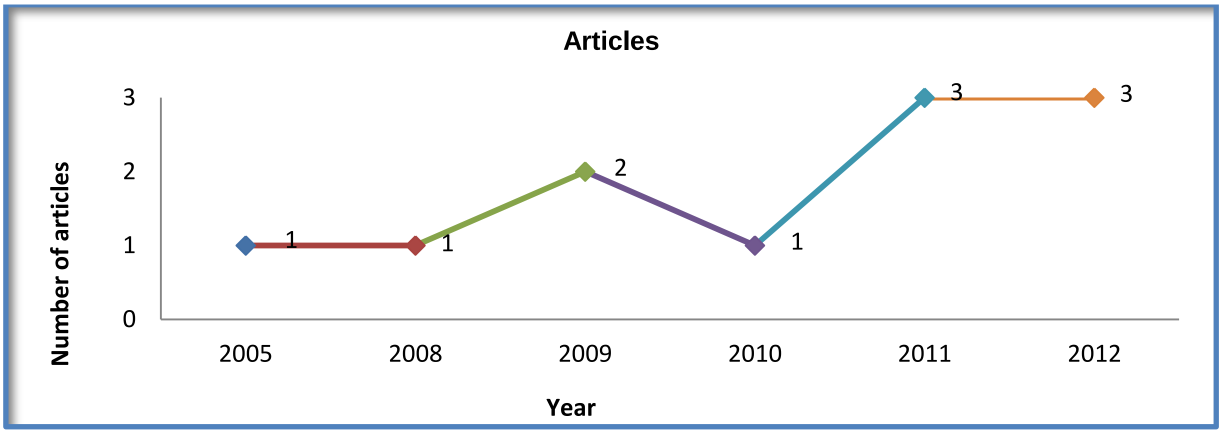

Figure 2:9 Number of PSMTs articles published between 2005 and 2012

According to Yigit (2014) beliefs related to teachers' knowledge have been refined through the pre-service, in-service as well as technology development programmes. A total of eleven studies were conducted based on the PSMTs TPACK framework, while twelve studies investigated the measurement of this concept. The results show that the number of TPACK studies investigating PSMTs have not increased drastically during this period (2005 to 2012). In 2005, 2008 and

2010 few studies were conducted because the TPACK framework was still at its inception stage. Between 2011 and 2013 the number of studies increased as the TPACK framework became stable and many researchers started using it in their studies.

Lee and Hollebrands (2008) utilised the TPACK framework to create an assessment tool in order to measure the PSMTs' understandings of a mathematical thought. Furthermore, the TPACK framework was utilised to look at the emergence of PSMTs' TPACK during a training course that exposed PSMTs to the planning and execution of the technology driven activities (Özgün-Koca, Meagher, & Edwards, 2010). Based on Yigit (2014) publication various writers made use of the TPACK framework to evaluate the construction of PSMTs' TPACK knowledge (Haciomeroglu, Bu, Schoen, & Hohenwarter, 2011).

Various authors also investigated how PSMT educators utilised ICT to improve PSMTs' personal TPACK, and to determine the suitability of ICT in the development of PSMTs' TPACK components (Larkin, Jamieson-Proctor, & Finger, 2012). The development of this framework has provided educationists and researchers with a tool that can be used to determine the effectiveness of how teachers integrate technology into their classroom practices. It describes an integrated connection between content knowledge, pedagogical knowledge and technological knowledge. In conclusion, Yigit (2014, p. 30) indicated that the majority of these researchers have emphasised that the "TPACK framework could be used to develop assessments and to identify the development of PSMT's knowledge and their understandings of the lesson or the course, and to design instructions, activities and practices throughout the lesson or the course they created".

2.16 Studies that have used factor analysis

Table 2:4 shows the number of studies that have been conducted since 2008 to 2014 using factor analysis techniques as well as different rotational methods.

Table 2:4 Studies that have used factor analysis as well as different rotational methods

Author(s) and Year	Types of factor analysis	Rotation method
Chai, Koh and Tsai (2010), Koh and Sing (2011) and Shinas, Yilmaz-Mouza, Karchmer-Klein & Glutting (2013)	Exploratory Factor Analysis	Not specified
Karadeniz and Vatanartiran (2013)	Confirmatory Factor Analysis	Not specified
Chai, Koh and Sing (2011)	Exploratory and Confirmatory Factor Analysis	Not specified
Koh, Chai and Tsai (2010)	Exploratory Factor Analysis and Principal Component Analysis	Not specified
Albion, Jamieson-Proctor and Finger (2010)	Factor Analysis using Principal Axis Factoring	Oblimin rotation
Archambault and Barnett (2010)	Factor analysis	Verimax rotation
Schmidt, Baran, Thompson, Mishra and Shin (2009)	Principal factor analysis	Verimax rotation
Lee and Tsai (2008)	Exploratory Factor Analysis, Principle Factor Analysis and Confirmatory Factor Analysis	Verimax rotation

These studies have used factor analysis to examine the collected data. Exploratory factor analysis (EFA) has been used in 60% of the studies, while 30% of the studies used confirmatory factor analysis (CFA). Data rotational methods were used in 40% of the studies (Verimax (30%) and Oblimin rotational (10%) methods) while 60% did not specify.

2.17 Gaps identified in the literature

The Categorical Principal Component Analysis (CATPCA) procrustean rotation technique and the Tucker congruent coefficient statistical analysis have not been used simultaneously in the articles analysed in this study. Furthermore, the Orthosim software has not been used in the previous TIMSS studies to calculate the relationship between teachers' self-reported beliefs. These are the gaps that were identified during the literature review and prompted the researcher to employ them in order to seek answers to the research questions.

2.18 Conceptual framework used in this study

Figure 2:10 depicts the conceptual framework used in the study to answer the research questions. The study was established based on the interaction between these two main assumptions, namely teachers' beliefs as well as the TPACK framework.

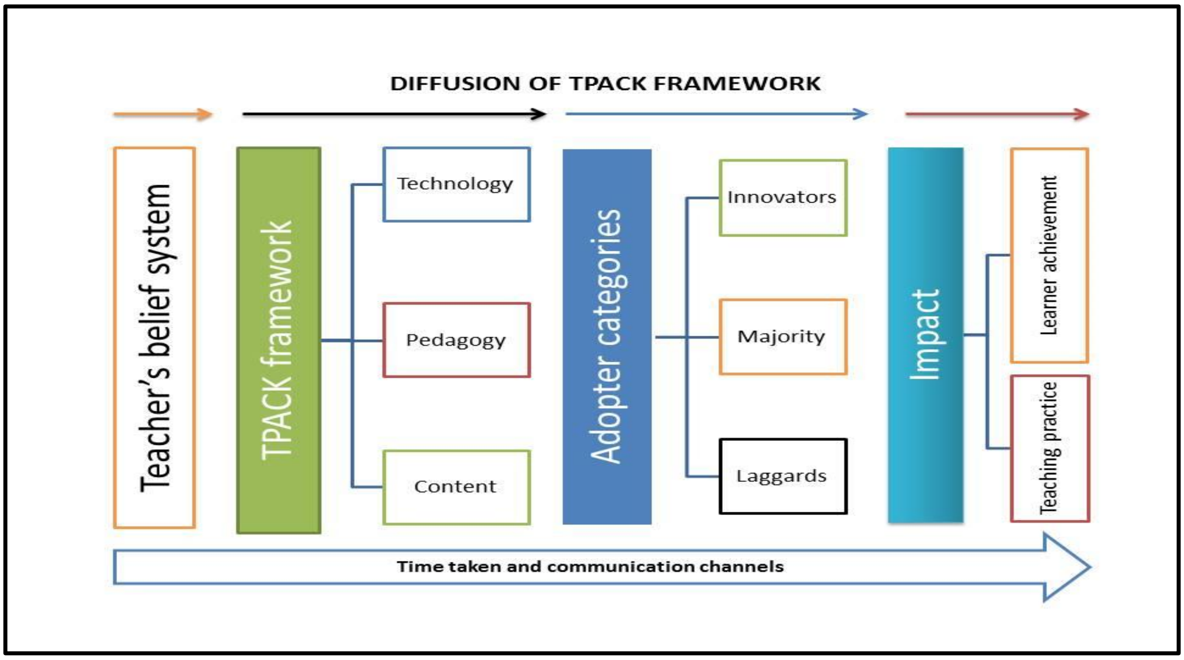

Figure 2:10 Conceptual framework used in this study

Angeli and Valanides (2009, p. 57) indicated that the present TPACK framework "does not take into consideration other factors beyond content, pedagogy and technology, such as for example teachers' epistemic beliefs and values about teaching and learning that may also be important to take into account".

The conceptual framework used in the study has brought together teachers' beliefs, classroom practices as well as the constructs from the TPACK framework. The framework indicates how the beliefs held by teachers influence the teaching and learning practices using the constructs from the TPACK framework. Researchers advocate that beliefs are the most important force that has an effect on teaching and learning (Calderhead, 1996; Pajares, 1992; Thompson, 1992). Furthermore, additional factors which influence teaching practice, include amongst others, pedagogical knowledge, teachers' subject matter knowledge and pedagogical content knowledge (Koehler & Mishra, 2008; Yigit, 2014).

Teaching with technology does not happen in an isolated manner but rather in a particular context (Koehler & Mishra, 2008). Teachers should acquire new skills that will enable them to integrate knowledge about learners in order to teach well with technology. It is evident that the TPACK framework outlines the characteristics of an ideal teacher who is able to integrate educational technologies into the classroom practice. The introduction of computers into teaching and learning is believed to have a bearing on the role of a teachers as well as shifting their beliefs from a didactic to a constructivist approach (Bracey, 1993). It is imperative for researchers to understand the underlying theoretical issues that underpin teachers' beliefs about the integration of technology into teaching and learning (Hannafin & Savenye, 1993).

It is clear from Roger's (1995) DoI theory that the adopter categories within a social system can be classified as communities of practice. A community of practice (CoP) is formed "when a group of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger-Trayner & Wenger-Trayner, 2015, p. 1). Therefore, a CoP develops when two or more people who share a common interest in an area under discussion collaborate over an extended period of time in order to build innovations or solutions. In addition, communities develop their practice through calls for information, mapping knowledge and identifying gaps (Wenger-Trayner & Wenger-Trayner, 2015). For Wenger-Trayner and Wenger-Trayner (2015), learning is central to human identity as such individuals continuously create their shared identity through engaging in, and contributing to, the practices of their communities. In addition, the motivation to become a participant in a community of practice has the potential of providing a powerful incentive for learning.

2.19 Conclusion

Chapter 2 provides an account of the literature reviewed exploring the large scale international comparative studies such as PISA, FIMS, SIMS, as well as TIMSS. Furthermore, the study explored the TPACK theoretical framework and how it has been adapted for the purpose of this study.

Chapter 3 will provide a detailed description about the research design that was used of in this investigation. It discusses the rationale for the quantitative design, the sampling procedure, the data gathering instrument, the research questions, the ethical considerations and the justification of the research. It also describes the data exploration procedures, the delineation and the limitations of the study.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodologies used in this study. Furthermore, it is meant to provide the reader with a foundation for appraising the legitimacy of the research outcomes and for understanding the rationale for the choices that were made. In Sections 3.3 to 3.5, the research design covering sampling and data collection is clarified. In Section 3.6 the current study, which encompasses the fundamental beliefs upon which this study is based, are explained. The type of instruments used as part of the previous TIMSS 2011 study and the current study are explained in Section 3.7. Finally, the limitations of the research methodology are stated before the chapter is concluded.

3.2 Trends in Mathematics and Science Study (TIMSS)

Like other international studies, TIMSS is conducted to evaluate how learners in various countries are capable of solving mathematics and science problems at different phases (fourth and eighth grade) of their schooling (Martin et al., 2012). Therefore, these international comparative studies are very important in view of the fact that they provide educationists and various governments with relevant information to understand learner performance, as well as a foundation for enhancement (Plomp, 1998; Postlethwaite, 1988). These studies have compelled countries across the world to provide schools with appropriate educational resources to accelerate and improve the quality of basic education.

The International Association for the Educational Achievements (IEA) is a sovereign organisation located in the Netherlands and it comprises of national research institutions and governmental research agencies (Mullis, Martin, Minnich, et al., 2012). This organisation’s mandate is to conduct large scale comparative studies about learner achievement in various countries worldwide (Mullis & Martin, 2006). The IEA encourages countries to participate in these international comparative studies by providing selected schools with incentives, such as financial support (Reddy, 2006). At the end of these studies, the IEA produces a comprehensive report regarding the outcomes of the research.

TIMSS international comparative studies about learner achievements have been carried out by the IEA since 1995 (Mullis et al., 2004). Furthermore, TIMSS international comparative studies are conducted on a fixed four-year cycle to evaluate fourth and eighth/ninth grade learners' mathematics and science achievements. Figure 3:1 exhibits that there are five TIMSS studies that were carried out over a period of time from 1995 to 2011. However, in 2007 South Africa chose not to participate in the TIMSS assessment (DBE, 2013).

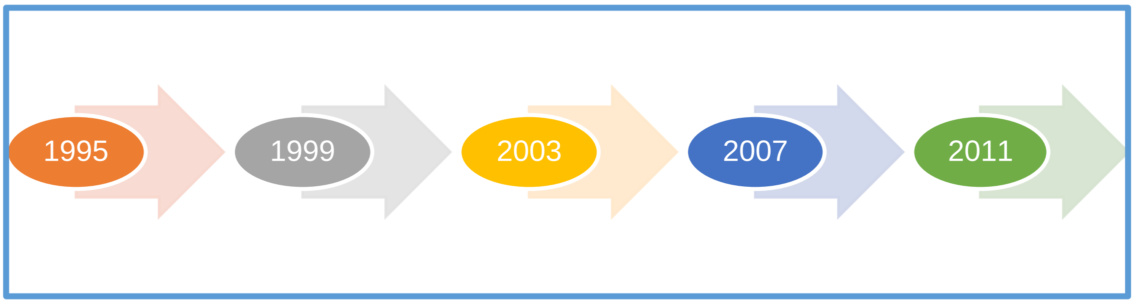

Figure 3:1 TIMSS studies conducted since 1995 to 2011

TIMSS is viewed as an endeavour that investigates the effectiveness of the curriculum and classroom strategies in relation to learners' attainment in the participating countries (Hencke, Rutkowski, Neuschmidt, & Gonzalez, 2009). In South Africa, Grade 9 learners and teachers were selected to participate (the sampling procedure is discussed in Sections 3.4 and 3.9). The rationale for the selection was based on the assumption that the content on the TIMSS 2011 assessment was adequate in Grade 9 and not Grade 8 for South African learners. TIMSS studies are used to compare Grade 4 and Grade 8/9 learners' performance in mathematics and science. These studies are grounded on an effort to understand various education systems globally, based on the investigation of curricula coverage, teaching practices and being compared with the students' achievements (Mullis et al., 2004).

3.3 Research design

It should be noted that only seven, out of the 59 countries who participated in TIMSS 2011, were analysed as part of this research. These seven selected countries are grouped according to the government expenditure on education values extracted from the TIMSS 2011 Encyclopedia. These countries were demarcated into two distinct groups, namely countries with lower, and higher, government expenditure on education than that of South Africa. In this study no additional information was collected from the participants - only data collected during TIMSS 2011 was utilised in this study.

3.3.1 Population

A research population is defined as any assemblage of entities that the researcher is interested to explore and that can be established at a particular point in time (Cohen & Manion, 2007). There were 12 189 teachers and 305 034 learners from 59 countries who participated in the TIMSS 2011 study (Joncas, 2012). The interested reader is referred to Annexure A for the list of the 59 countries. The population of the study consists of Grade 8 and Grade 9 mathematics learners who participated during the TIMSS 2011 study according to their teachers' viewpoint. These mathematics teachers taught learners who had approximately eight years of education (Blignaut, Els, & Howie, 2010).

3.3.2 Sampling

Saunders, Lewis, and Thornhill (2009) define sampling as a procedure that a researcher employs to choose a certain number of respondents from the population. Furthermore, Creswell (1998, p. 110) agrees and articulates sampling as a "process of finding people or places to study; gain access to study, and establish a rapport so that participants provide relevant data". The main goal of selecting a sample is to acquire a specimen that is representative of the chosen population (Cohen & Manion, 2007; Saunders et al., 2009). A sample is therefore regarded as the subset of the population that is being researched, or a microcosm of the population from which the study will be drawn (Saunders et al., 2009). In addition, a representative sampling procedure is seen as a process of identifying and selecting members for a study in such a manner that they represent the population they have been drawn from.

Cohen and Manion (2007, p. 101) indicated that a sample size of thirty is considered by numerous scholars to be the "minimum numbers of cases if researchers plan to use some form of statistical analysis". Various authors have agreed that, if the sample size is large there is a likelihood that the outcomes of the research can be generalised to the entire population where it was selected (Greener, 2008; Mertens, 1998; Saunders et al., 2009). It has been argued by Zikmund (2003) that sample size has a great effect on how the sample findings accurately represent the population. Non-probability and probability sampling are two forms of selection techniques that can be used in any research project (Saunders et al., 2009; Zikmund, 2003). These authors indicated that both of these sampling techniques can be used in a research study and can take different forms depending on the nature of the study.

3.4 Sampling used in the TIMSS 2011 study

As stated by the Mullis, Martin, Foy, et al. (2012) the TIMSS 2011 study used two target populations, namely, population 1 (comprising of mostly nine year-olds during the period of assessment) and population 2 (consisting mainly of thirteen year-olds during the period of appraisal). This study focused on population 2, which consists of Grade 8 mathematics learners and their mathematics teachers. However, as mentioned before, in South Africa Grade 9 learners and their mathematics teachers participated in the study.

According to the Mullis, Martin, Foy, et al. (2012) the primary sample employed during the TIMSS 2011 study was a two-stage random sampling technique. During the initial stage schools were sampled from the database of all schools that have learners who met the TIMSS selection requirements. The target population was Grade 8/9 learners studying mathematics in the participating countries during the time of assessment. Thereafter, all the chosen schools were classified according a well-defined set of demographic variables, such as region, and whether the school is in an urban or a rural area. The second stage involved the selection of one or more intact class from the target grade of each nominated schools. It is in this regard that all the learners in the selected classes participated in the evaluation.

A total number of 9 741 schools (Annexure A) were sampled in the initial phase, and in the second phase, classrooms within those schools were selected. In each of the selected schools, a Grade 8/9 mathematics classroom was identified to participate in the TIMSS 2011 assessment. The mathematics teacher of the sampled classroom was the one who completed the mathematics teacher questionnaire.

3.5 Data collection and instruments

Data gathering is described as the epicentre of the research project where the researcher is engaged with the participants, in an endeavour to seek answers to the research questions that is at hand (Birley & Moreland, 1998). The TIMSS 2011 study administered a wide range of questionnaires that encompassed the following: a school questionnaire, a learner and a teacher questionnaire (Mullis, Martin, Foy, et al., 2012). The data collection instruments are available at the TIMSS 2011 website (https://timss.bc.edu/timss2011/international-contextual-q.html).

3.5.1 School questionnaire

The school questionnaire was completed by the principal of each sampled school according to the prescripts as laid down by the IEA. This school questionnaire was meant to collect information regarding the schools' context, and other factors that could influence learner achievement in mathematics.

3.5.2 Learner questionnaire

The learner questionnaire collected data pertaining to learners' background, resources used for classroom instructions, and learners' attitudes and experiences in learning mathematics. This questionnaire also collected information regarding the factors that influences learner performance in mathematics.

3.5.3 Teacher questionnaire

The prevalent method used to gather data from teachers during the TIMSS 2011 study was the teacher's questionnaire. The questionnaire was about mathematics teachers' beliefs on issues with regards to their curriculum framework, teaching and learning approaches, professional development and finally, also their pedagogical strategies used in the classroom (Martin et al., 2012; Mullis, Martin, Foy, et al., 2012). The questionnaire was managed at a national level where mathematics teachers of sampled schools replied to questions about instructional strategies, among others. The data collection instrument included Likert scales that were used to measure attitudes that required teachers to choose a statement from a number of statements.

Teachers chose from a set of statements where each response was assigned a weight that allowed the researcher to perform statistical analysis (Saunders et al., 2009; Zikmund, 2003). Zikmund (2003) points out that the option that the participants selected indicated to what extent they agreed on the choice made. The emphasis was on:

- Areas in the curriculum framework;
- Teaching practices;
- Professional teacher training and instruction; and
- Teacher's opinions in relation to classroom instruction (Robitaille, 1997).

The teachers' responses in TIMSS 2011 are not necessarily representative of all the teachers in South Africa and their international counterparts compared with, as these teachers are representative of the samples of learners assessed. It is imperative to remember that a mathematics classroom was randomly selected and the teachers who taught them were automatically included in the study (Joncas & Foy, 2013; Wu, 2010). The teachers' responses about instruction were directly linked to the learners appraised and the exact mathematics classes in which they were taught. This included items that assessed the attitudes and values of teachers. A variety of questions were asked that probed the opinions and preferences of respondents. However, well thought-out questions, which related to the examination of attitude, could provide insights that are exceptionally significant and reveal critical information. To this end, this study relied heavily on the opinions, beliefs and attitudes of these Grade 8/9 mathematics teachers.

3.6 Current study

3.6.1 Fundamental beliefs

The current study was aimed at determining how South African learners compared with their selected six international counterparts in the TIMSS 2011 study, by focusing on their use of computers (*technology*), their instructional strategies (*teaching strategies*) and on content coverage (*specific content*). It should be noted that these philosophical questions modelled the basis of the researcher's belief system (Guba & Lincoln, 1994). Therefore, this research was structured in such a way that the boundaries were established and that the fundamental research questions could be answered. Lather (1986, p. 259) believes, that “research paradigms inherently reflect our beliefs about the world we live in and want to live in.” Guba and Lincoln (1994) mentioned that a research paradigm is an endeavour that intends to offer feedback grounded on ontological, epistemological and methodological questions.

3.6.2 Ontology

Ontology is defined as the discipline or a study looking into the existence of being, because it encompasses “claims about what existence looks like, what units make it up and how these units interact with each other” (Blaikie, 1993, p. 8). Furthermore, ontology is also regarded as "a branch of philosophy concerned with articulating the nature and structure of the world” (Wand & Weber, 1993, p. 220). Various authors concur with Blaikie (1993) that ontology is a lens through which the scholar or investigators perceive the nature of reality (Gephart, 1999; McGregor & Murnane, 2010; TerreBlanche & Durrheim, 1999). These writers pointed out that the researcher’s lens of reality could take various forms, such as the objective reality that exists, or a subjective reality that is formed in the mind of the researcher. An ontological stance with realist foundations provides the basis for this study. Realism is defined as a research philosophy that possesses the principles of both interpretivism and positivism (Blumberg, Cooper, & Schindler, 2011, p. 19). The realists belief that reality may not exist without continuous research and thus afford researchers the opportunity to use new methods of research. Furthermore, realism researchers believe that scientific methods are not perfect and that all theory can be revised (Blumberg et al., 2011).

3.6.3 Epistemology

According to Saunders et al. (2009, p. 501) epistemology is a branch of philosophy “that studies the nature of knowledge and what constitutes acceptable knowledge in a field of study” or “how we know what we know” (Crotty, 1998, p. 8). Furthermore, Eriksson and Kovalainen (2008, p. 14) alluded to the fact that epistemology encompasses “what is knowledge, what are the sources and limits of knowledge”. A rational approach was adopted in this study as the researcher should be able to provide a response or answers to the following epistemological question (Guba & Lincoln, 1994, p. 108): “What is the nature of the relationship between the knower or would-be knower and what can be known?” The epistemological framework for this study is post-positivism.

3.6.4 Post-positivism

Various authors agree that the limitation experienced by the positivist approach has led to the development of the post-positivist approach (Guba & Lincoln, 1994; Muijs, 2004). Post-positivism is perceived as an alternative of the previous positivist paradigm, however, both believe in the possibility of an objective reality (Della Porta & Keating, 2008). These authors further indicated that post-positivism is “closer to modern scientific approaches, which accept a degree of uncertainty” (Della Porta & Keating, 2008, p. 24). In post-positivist research, truth is generated through a process of exchanging ideas where justifiable knowledge assertions emerge based on the interpretations of the results (Winfield, 1990). It is based on these assumptions that post-positivists are in agreement that the world could not be observed as wholly objective and that natural sciences do not provide a model for all social research. In addition, post-positivism accepts that this “reality” is only “imperfectly and probabilistically apprehendable” (Guba & Lincoln, 1994, p. 109).

More explicitly, a researcher who is using this belief system, is engaged with matters that were put forward during the interviews, the participants’ responses, and the researcher’s understandings of these intertwined thoughts. Therefore, in this investigation a post-positivist paradigm is employed. Post-positivism claims that an individual can make acceptable deductions about an occurrence by using both logical judgement as well as empirical observations (Bhattacherjee, 2012). According to Bhattacherjee (2012) post-positivists’ science is viewed as “probabilistic” and often seeks to explore these unforeseen circumstances to enable them to be familiar with social reality.

3.7 Research approach

It has been argued by Kaplan (1973) that if methods denote the procedures and techniques employed to gather data, then the purpose of methodology is to provide details about the methods and research paradigms. Borrowing from Kothari (2004) research methodology is utilised as a vehicle to allow the researcher to understand the research process and provide outcomes after conducting a scientific investigation. Furthermore, Creswell (1994) views methodology as a strategy of activities or a blueprint that controls the selection of a variety of methods that are used in any investigation. This blueprint is regarded as a conduit through which the researcher establishes methods using a structured process to discover potential solutions to the research questions.

In this enquiry a quantitative methodological approach was used to provide answers to the research questions in order to achieve the research purpose (Bryman & Bell, 2007). Various authors attest to the fact that in a quantitative exploration the researcher uses statistical procedures to collect and analyse data (Cohen & Manion, 2007; Saunders et al., 2009).

As pointed out by Bless and Higson-Smith (2000), quantitative research is carried out using a wide range of techniques, which makes use of statistics to document and look at facets of social reality. Likewise, Leedy and Ormrod (2005) indicate that a quantitative approach is used when the researcher is interested in determining relationships, or deciding whether a cause produced a specific effect. When conducting quantitative research, the researcher should be able to answer the following methodological question (Guba & Lincoln, 1994, p. 108): “How can the inquirer go about finding out whether whatever he or she believes can be known?”

Quantitative research is objective and uses a deductive approach to acquire knowledge (Greener, 2008, p. 17). Leach (1990) and Duffy (1985) use ‘empiricism’ and ‘positivism’ to define qualitative research. According to Cormack (1991) quantitative investigation is derived from the scientific method used in physical sciences and is guided by certain thoughts and views about the issue to be explored.

Furthermore, Bryman and Bell (2007) concur with these authors and define the two methodologies that underpin research as:

- A deductive approach where theory is deduced from the observations or findings; and
- An inductive approach where the observations or the findings are used to develop theory.

It can be concluded that the research approach depends on the problem that the research is trying to solve and the questions that the research is trying to answer. It is evident from these pronouncements that the researcher is responsible for choosing an ideal approach that can be used for any type of enquiry. Due to these assumptions, post-positivistic claims for developing knowledge and a quantitative approach to collect and analyse statistical data were used.

3.8 Research methods

The research method is regarded as a blueprint of an investigation, which moves from the fundamental assumptions based on the research design and data gathering strategies (Kothari, 2004). As alluded by various authors, methods signify a set of methodologies that are used during the data collection and analysis process (Cohen & Manion, 2007; Kothari, 2004). This collected information serves as the basis for making justifications and for drawing conclusions based on all those methods and techniques used in conducting the research (Kothari, 2004).

3.8.1 Secondary data analysis

In research circles it is well understood that data can be delineated into primary and secondary data (Bryman & Bell, 2007; Ghauri, Grønhaug, & Kristianslund, 1995; Saunders et al., 2009). Primary data is considered “as those which are collected afresh and for the first time, and thus happen to be original in character” (Kothari, 2004, p. 96). In addition, various authors have agreed that secondary data is regarded as documents, articles and literature that were previously collected by different scholars or organisations (Bryman & Bell, 2007).

This investigation was about the analysis of data collected during the TIMSS 2011 study and no additional data was collected. Secondary data analysis (SDA) is regarded as a process whereby existing data is identified and then used to examine and provide answers to a new situation (Heaton, 1998). That said, SDA consists of non-numeric and numeric data obtained from interviews, dialogues and ethnographic studies (Smith, 2008). Moreover, secondary data investigations talk about the pragmatic exercise that uses existing data for further analysis, applying either the original and/or dissimilar numerical techniques (Kothari, 2004; Smith, 2008). The same notion is also articulated by Vartanian (2010, p. 3) that “secondary data includes any data that are examined to answer a research question other than the question(s) for which the data were initially collected”. The above mentioned authors concur that secondary data analysis involves the use of previously completed datasets, to answer new questions that are different from the original study (Smith et al., 2011; Trzesniewski, Brent, & Lucas, 2010).

3.9 Sampling technique used in the present study

Figure 3:2 shows a three-phased sampling approach that was used to nominate countries that were analysed in this research. The participants were carefully chosen from all the countries that participated in the TIMSS 2011 study. The participants from the sample came from a diverse set of educational systems based on the socio-economic maturity, topographical setting and population proportions.

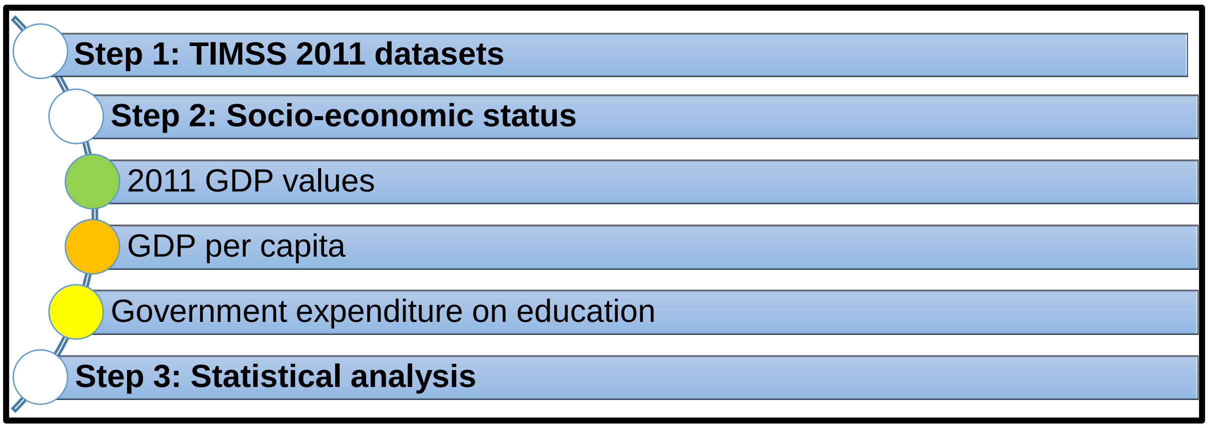

Figure 3:2 Selection criterions of the six countries

Figure 3:2 shows the framework that was employed to select all the countries that were examined in this research comprises of three steps, namely *TIMSS 2011 datasets*, *socio-economic status (2011 GDP values, 2011 GDP per capita values and government expenditure on education) and statistical analysis*.

Step 1: TIMSS 2011 datasets

The population extracted from the TIMSS 2011 study entailed 302 741 schools from the 59 countries that participated (see Annexure A). The reader is reminded that TIMSS did not directly sample teachers, but rather information about learners' data used and analysed in this study which was acquired from the teachers offering mathematics to the sampled classes. The teacher information is treated as a characteristic of the mathematics learners (Foy, Arora, & Stanco, 2011). For each participating school a single mathematics teacher of the selected mathematics class was requested to complete a self-reported mathematics questionnaire.

Step 2: Socio-economic status

Various authors indicated that when educational systems are compared worldwide, it is essential to take into consideration the significance of the different social, economic and political contexts into account (Crossley & Jarvis, 2000). Table 3:1 shows the characteristics of all the countries analysed in the study.

Table 3:1 Countries characteristics

Country Name	2011 GDP		2011 GDP per capita		Government expenditure on education	
	Billion US$	Ranking	US$	Ranking	% of GDP	Ranking
Saudi Arabia	671.20	1	23 770.75	5	6	2
Iran, Islamic Republic	592.00	2	7 842.43	8	5	3
Sweden	563.10	3	59 593.29	2	7	1
Norway	498.20	4	100 574.99	1	7	1
South Africa	**416.40**	**5**	**8 049.95**	**7**	**5**	**3**
Thailand	370.80	6	5 491.16	9	4	4
United Arab Emirates	350.90	7	40 462.31	4	1	6
Malaysia	298.00	8	10 405.12	6	4	4
Singapore	275.60	9	53 166.68	3	3	5

2011 GDP values

All the countries that participated during the 2011 TIMSS study were grouped according to their 2011 GDP values. It should be noted that the 2011 GDP values of the countries that participated were extracted from the World Bank website (Annexure B). GDP is defined as the overall worth of all goods and services produced over a specific period of time (World Bank, n.d.). The rationale for the using the GDP values was that countries with rich economies may be able to put in more financial resources to their education system than poor countries. Furthermore, the selection was based on the assumption that learners in countries with GDP values close to that of South Africa are performing well based on the TIMSS results. TIMSS results have shown that all these countries are performing better than South Africa in terms of learner achievements (Mullis & Martin, 2011; Mullis et al., 2004).

In this phase, countries with GDP values between 671.20 billion US dollars and 275.60 billion US dollars were selected. The sampling of these countries was based on the premise that their 2011 GDP values were close to that of South Africa (416.40 billion US dollars). The country (Saudi Arabia) with the highest GDP was at 671.2 billion US dollars while Singapore had the lowest (275.4 billion US dollars).

GDP per capita values

The researcher utilised the 2011 GDP per capita based on purchasing power parity (PPP) as another determining factors to select the countries that were compared with South Africa in this study. The 2011 GDP per capita values were extracted from TIMSS 2011 Encyclopedia. Table 3:2 shows that Norway had the highest GDP per capita (100 574.99 US dollars) while Thailand had the lowest (5 491.16 US dollars). For example, in a study conducted by Lynn and Mikk (2007) it was found that the TIMSS test scores for Grade 8 learners and GDP per capita had a correlation of 0.55. It should be noted that the GDP per capita values of these countries differs significantly.

Government expenditure on education

The government expenditure on education as a percentage of GDP was used as another determining factor. This value is defined as the overall government spending on education, expressed as a percentage of GDP. The government expenditure on education values were extracted from the TIMSS 2011 Encyclopedia. The analysis included countries with government expenditure on education values close to that of South Africa, based on the TIMSS 2011 Encyclopedia statistics. Table 3:2 shows that Sweden and Norway had the highest percentage (7) of government expenditure on education while United Arab Emirates had the lowest (1).

A total of nine countries were retained during the second instance and were split into two different categories, namely countries with higher and lower government expenditure on education as a percentage of GDP in relation to that of South Africa (Annexure C).

Step 3: Statistical analysis

Firstly, the factor analysis was applied to determine the structure of the learners' data linked to their teachers' responses. The data obtained from learners whose teachers provided responses was also tested to determine its appropriateness for factor analysis. Therefore, the test results of Kaiser Meyer-Olkin (KMO) and the Barlett's test of Sphericity were explored.

A factor analysis was carried out to identify the number of factors that should be retained for further analysis. The eigenvalues and the Keiser-Meyer Olkin (KMO) measures were scrutinised to ascertain the number of factors underlying the responses made by the Grade 8/9 learners. It should be taken into consideration that the eigenvalues are not represented by percentages, but scores of the total of the number of items. A variable with the KMO value of 0.5 is proposed as the least possible value for a good factor analysis (Tabachnick & Fidell, 2007). Thus, all the variables with KMO values lower than 0.5 were regarded as inadequate to be considered for factor analysis (Field, 2014). A KMO value lower than 0.5 shows that the sample size is not large enough to conduct a factor analysis. The closer the value is to one, the better. Even though factor analysis might be a suitable technique to implement, the factor analysis will not account for the substantial amount of variance in the data. As such, the variables with the lowest KMO values were excluded from the rest of the statistical analysis. Furthermore, optimal scaling was used before dealing with factor extraction to determine how many factors were to be retained as part of the analysis.

Table 3:2 indicates the results of the factor analysis which includes an adequacy of the sample that was measured using the KMO and Bartlett's tests of sphericity. The results set out in Table 3:2 are related to the use of computer activities, teaching strategies and teaching specific mathematics content.

Table 3:2 Factor analysis results

Countries	Computer activities			Teaching strategies			Content coverage		
	KMO	Bartlett's test		KMO	Bartlett's test		KMO	Bartlett's test	
		Chi-square	Sig.		Chi-square	Sig.		Chi-square	Sig.
Norway	0.570	4 111	0.00	0.707	5 741	0.00	0.819	54 253	0.00
Sweden	0.731	4 182	0.00	0.768	7 524	0.00	0.840	45 102	0.00
Saudi Arabia	0.790	2 709	0.00	0.781	6 103	0.00	0.742	35 654	0.00
South Africa	0.613	9 403	0.00	0.747	16 333	0.00	0.891	114 687	0.00
Thailand	0.662	4 911	0.00	0.817	23 171	0.00	0.866	61 149	0.00
Singapore	0.723	9 893	0.00	0.764	15 236	0.00	0.894	66 834	0.00
United Arab Emirates	0.767	9 550	0.00	0.759	19 226	0.00	0.872	96 972	0.00

It should be noted that the KMO values should be greater than 0.5 and the Bartlett's should be less than 0.05. The KMO values related to the **computer activities** were all greater than 0.5, and the statistical results of the Barlett's test of sphericity level of significance (p-values) were less than 0.001. The Bartlett's test confirmed that the characteristics of the correlation matrices for all the countries with higher and lower GDPs than South Africa, were appropriate for factor analysis (Field, 2009, p. 660).

The KMO values for the **teaching strategies** were similarly greater than 0.5, and the level of significance (p-values) of the Barlett's test of sphericity were less than 0.001. Bartlett's test confirmed that the characteristics of the correlation matrices for all the countries with higher and lower government expenditure on education than South Africa, were appropriate for factor analysis.

The KMO values regarding the **content coverage** were, once again, all greater than 0.5, and the s level of significance (p-values) of the Barlett's test of sphericity were less than 0.001. Therefore, Bartlett's test confirmed that the characteristics of the correlation matrices for all the countries compared to South Africa, were appropriate for factor analysis.

The value of the Bartlett test of sphericity indicates that an identity matrix was not produced by these data; therefore they were acceptable for factor analysis. These two analytic tests (KMO and Bartlett's test) yielded satisfactory results (in terms of teaching strategies, computer activities and content coverage) for all seven selected countries used in this study. It is clear from the results that these seven countries, namely Norway, Sweden, Saudi Arabia, South Africa, Thailand, Singapore and United Arab Emirates, satisfied the set criterion. All the countries within the selected government expenditure on education close to that of South Africa and with component loadings lower than 0.5 not adhering to the Keiser's criterion, were discarded.

In the last instance only six countries that had government expenditure on education values close to that of South Africa were selected. It is in this context that Norway, Sweden, Saudi Arabia, South Africa, Thailand, Singapore and the United Arab Emirates all satisfied the set criteria and were used in the study. It should be noted that there were three countries with higher (Norway, Sweden, Saudi Arabia) and three countries with lower (Thailand, Singapore and the United Arab Emirates) government expenditure on education in relation to that of South Africa.

While GDP reflects the amount of money a country makes and GDP per capita reflects the average income (earned and unearned) per person in a country, in this study the final step, for selecting the countries, depended on expenditure on education as a percentage of GDP. The reason why expenditure on education as a percentage of GDP was used in this study, as opposed to only considering GDP or GDP per capita is as follows. Countries that are richer tend to have an older population and, consequently, the government spends more on social security (Shelton, 2007, p. 2231 and 2255). On the other hand, poorer, less-developed countries tend to spend more on education (Shelton, 2007, p. 2251). Thus, considering the GDP or GDP per capita on its own is not sufficient. The question on what percentage the government is spending on education is important and therefore considered in this study.

3.10 Data collection

In this study the TIMSS 2011 Grade 8/9 mathematics teachers' datasets, which were obtained from the TIMSS website accessible online, were used. Teachers chose from a set of statements where each response was assigned a weight, in the form of a Likert scale, which allowed for statistical analysis to be performed (Saunders, Lewis, & Thornhill, 2007; Zikmund, 2003). Furthermore, the Likert scale option that the participants selected, indicated to what extent they disagreed, or agreed, with a statement.

The purpose of this study was to draw a comparison between South African learners and their six counterparts that participated in the TIMSS 2011 study. The comparison was done focusing on the teachers' reports about the use of computer activities, instructional strategies and content coverage. Therefore, the selection of the questions analysed in this study were based on the TPACK framework. The emphasis was based on teachers' beliefs related to their computer activities, teaching strategies as well as content coverage. The following questions were selected and analysed based on the TPACK framework, namely:

a) Question 19B and Question 22C from the TIMSS 2011 Teacher Questionnaire (see Annexure D). It is referred to as **Computer activities** in this study;

b) Question 19 from the TIMSS 2011 Teacher Questionnaire (see Annexure E). It is called **Teaching strategies** in this study; and

c) Question 30 from the TIMSS 2011 Teacher Questionnaire (see Annexure F). It is specified as **Content coverage** in this study.

3.11 Research questions used in this study

In this study, a number of research questions were formulated, investigating whether significant similarities exist between South Africa and its international counterparts who participated in the TIMSS 2011 study.

Research question 1: Computer activities

How do South African learners compare with their selected international counterparts with regards to how their teachers have used different **computer activities**?

Factor analysis was performed based on all seven (7) statements with regards to the teachers' viewpoints on the use of computers, as extracted from the questionnaire. Each of the statements in the questionnaire signified a teacher's viewpoint regarding the use of computers in their mathematics classroom. These teachers' opinions were appraised based on their eigenvalues and their KMO value.

Research question 2: Teaching strategies

How do South African learners compare with their selected international counterparts with regards to how their teachers have used different **teaching strategies**?

Factor analysis was performed based on all eleven (11) statements, or teachers' opinions as extracted from the questionnaire. Each of the statements in the questionnaire indicates the teacher's views regarding specific teaching strategies employed in his/her mathematics classroom. These teachers' opinions were appraised based on their eigenvalues and their KMO value.

Research question 3: Content coverage

How do South African learners compare with their selected international counterparts in respect of their teachers' preparedness to teach **specific mathematics content**?

Factor analysis was performed based on all nineteen (19) items or teachers' opinions as extracted from the questionnaire. Furthermore, each of the statements in the questionnaire signified a teacher's viewpoint about how well prepared they felt to teach specific mathematic topics in his/her mathematics classroom. Similar to the other questions, these teachers' opinions were appraised based on their eigenvalues and their KMO value.

3.12 Data analysis

The data analysis techniques employed in this study were descriptive, as well as inferential statistics. Furthermore, factor analysis, CATPCA, orthogonal factor rotation and Tucker congruent coefficient techniques, were utilised and are described in Section 3.13. The researcher utilised the IEA International Database Analyzer (IDB) version 4.0, Statistical Package for the Social Sciences (SPSS) version 22 and Minitab version 17.3 to analyse data obtained from the TIMSS 2011 dataset. Furthermore, MS Excel was used to draw graphs derived from the data obtained from the TIMSS 2011 dataset.

3.12.1 Descriptive statistics

Descriptive statistics typically include some measure of central tendency, such as the median or mean, and the association between variables (Cohen & Manion, 2007). The descriptive statistics were done for variables such as gender, educational qualifications of teachers as well as the use of computer activities. The demographic variables collected, by means of the teacher questionnaire, were analysed descriptively and presented using graphs. Table 3:3 presents the questions that were extracted from the teachers' questionnaire and that were analysed in this study by making use of descriptive statistics.

Table 3:3 Questions used in this research as part of the descriptive statistics

<table>
<tr><th>Question</th><th>Description</th><th>Choice</th><th>Codebook</th><th>Measurement</th></tr>
<tr><td rowspan="3">1</td><td colspan="4">Gender</td></tr>
<tr><td rowspan="2">Are you male or female</td><td>1</td><td>Male</td><td>Nominal</td></tr>
<tr><td>2</td><td>Female</td><td>Nominal</td></tr>
<tr><td rowspan="3">5</td><td colspan="4">Educational qualifications</td></tr>
<tr><td rowspan="2">During your college or university, what was your major or main area(s) of study?</td><td>a)</td><td>Mathematics</td><td>Nominal</td></tr>
<tr><td>f)</td><td>Education mathematics</td><td>Nominal</td></tr>
<tr><td rowspan="4">9A</td><td colspan="4">Use of computer in teaching</td></tr>
<tr><td rowspan="3">Do you use computers in your teaching in any of the following?</td><td>a)</td><td>For preparation</td><td>Nominal</td></tr>
<tr><td>b)</td><td>For administration</td><td>Nominal</td></tr>
<tr><td>c)</td><td>In your classroom</td><td>Nominal</td></tr>
</table>

Frequency distributions were generated in SPSS in order to examine whether there were missing values and to confirm the percentage of respondents who provided their viewpoints.

3.12.2 Inferential statistics

The researcher employed optimal scaling to manipulate the factor loadings extracted from each of the following variables, namely computer activities, content coverage and teaching instructions, into component loadings. Tables 3:4 to 3:6 list the questions that were extracted from the teachers' questionnaire and that were analysed in this study as part of the inferential statistics. The interested reader is referred to Annexures D, E and F.

Table 3:4 presents the questions related to the use of computers that were extracted from the teachers' questionnaire and that were analysed in this study.

Table 3:4 Computer activities

Question	Computer activities	Choice	Codebook	Measurement
Question 9 (3 Items)	How much do you agree with the following statements about using computers in your classroom instruction?	1	Agree a lot	Ordinal
		2	Agree a little	Ordinal
		3	Disagree a little	Ordinal
		4	Disagree a lot	Ordinal
Question 22 (4 Items)	How often do you have the learners do the following computer activities during mathematics lessons?	1	Every or almost every day	Ordinal
		2	Once or twice a week	Ordinal
		3	Once or twice a month	Ordinal
		4	Never or almost never	Ordinal

Table 3:5 presents the questions related to teaching strategies that were extracted from the teachers' questionnaire and that were analysed in this study.

Table 3:5 Teaching strategies

Question	Teaching strategies	Choice	Codebook	Measurement
Question 19 (11 items)	In teaching mathematics to this class, how often do you usually ask learners to do the following?	1	Every or almost every lesson	Ordinal
		2	About half the lessons	Ordinal
		3	Some lessons	Ordinal
		4	Never	Ordinal

Table 3:6 presents the questions related to teaching specific content that was extracted from the teachers' questionnaire and that were analysed in this study.

Table 3:6 Content coverage

Question	Content coverage	Choice	Codebook	Measurement
Question 30 (19 Items)	How well prepared do you feel you are to teach the following mathematics topics?	1	Not applicable	Ordinal
		2	Very well prepared	Ordinal
		3	Somewhat prepared	Ordinal
		4	Not well prepared	Ordinal

All the variables used in the study were nominal or ordinal in nature. Nominal data indicates non-numerical variables that are assigned numerical values to serve as labels (Cohen & Manion, 2007). Furthermore, ordinal data is non-numerical variables that are placed in some scale or order. It should be noted that the distance between each point on a nominal data scale is not equal.

3.13 Procedure for analysis data

As specified by Muijs (2004), data analysis is the final step as soon as the data has been gathered. Thus, data analysis is regarded as a process where the researcher manipulates the collected data from the participants, in order to make sense and reach certain findings pertaining to the sample (Cooper & Schindler, 2008). The statistical procedures that were employed for data analysis are presented in Sections 3.13.1 to 3.13.5. It has been argued that if a sample size is larger than hundred, then factor analysis can be used (Hair, Black, Babin, Anderson, & Tatham, 2006). Since the sample size of the TIMSS data set is larger than hundred, factor analysis was utilised in this study.

3.13.1 Factor analysis

Factor analysis is used to ascertain the underlying conceptual configuration in a set of items (Bhattacherjee, 2012; Coolidge, 2000). Factor analysis is about clustering together and reducing items that have similar constructs based on their underlying factors (Cohen & Manion, 2007). There are two forms of factor analyses namely, confirmatory (CFA) and exploratory (EFA). The difference is that EFA is used to generate theory whilst the CFA was conducted to confirm whether the theoretical factor structure could be supported (Kline, 2012). EFA, that is sometimes regarded as Principal Component Analysis (PCA), was utilised in this study to ascertain the underlying structure of variables based on the selected set of items (Skrondal &

Rabe-Hesketh, 2004, p. 70). Kaiser (1974) recommends accepting values that are more than 0.5. Furthermore, the KMO values “between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great and values above 0.9 are superb” (Field, 2009, p. 647).

Factor analysis was carried out using an approach known as Kaiser’s criterion and was done to confirm the suitability of the number of factors to be retained (DeVellis, 1991). This technique was used to ascertain whether a set of items was suitable for factor analysis by looking into the sample size and the strength of inter-item correlation. Various authors suggested retaining factor(s) with eigenvalues that are equal to or greater than one (Krol et al., 2001; Meulmann & Heiser, 2005). If too many factors are extracted, it is recommended that the number of dimensions in a solution be increased only if the number of factors still explains a reasonable amount of the total variance. The researcher adopted two measures, namely the KMO value and Bartlett’s test of sphericity in this study. As espoused by Field (2009), the KMO value, of all the variables to be retained, was regarded as at least 0.5 or above, while the p-value for Bartlett’s Test of Sphericity should have been less than 0.05.

3.13.2 Categorical Principal Component Analysis (CATPCA)

The nominal data, extracted from the TIMSS 2011 teacher questionnaire for this study, was not in the correct format to be used in the regression modelling. As a result, the nominal data derived from the questionnaire was analysed by means of the optical scaling method using Categorical Principal Component Analysis (CATPCA), in order to transform them into quantifiable data. The CATPCA has the nonlinear abilities which make it equivalent to PCA because it can pursue interrelated objectives (Meulman, Van der Kooij, & Heiser, 2004). The CATPCA method encompasses nominal, ordinal (attributes are clearly ordered) as well as numeric variables as it transacts with nonlinear relationships among variables (Lingting, 2007). For that reason, this data analysis method is a multivariate technique that possesses exploratory ability to uncover the relations among the categories of qualitative variables (Meulmann & Heiser, 2005). It also has the ability to deal with categorical variables.

The purpose of CATPCA is to reduce the original set of categorical factors into lesser sets of quantitative factors that still account for most of the variance in the original information (Krol et al., 2001; Werkman, Boonstra, & Van der Kloot, 2005). It is utilised to find ideal scores for categorical variables by diminishing the dimensionality of information and changing categorical factors into quantitative factors utilising ideal measurement (Brentari, Golia, & Manisera, 2006). This is accomplished by utilising a numerical calculation known as Alternating Least Squares (ALS) that distributes numerical values to nominal and ordinal information, respectively. This strategy gives an ideal evaluation to each category of the qualitative factors (Molinero, Portillo, & Hayes, 2007). In effect, categorical variables are changed into numeric factors in a way so that the intensity of the connections among evaluated factors is optimised, which implies that ordinal or nominal information in the categorical variables is still kept in the optimal quantifications (Brentari et al., 2006).

The CATPCA output consists of the eigenvalues related to each retained dimension and the total percentage of variance accounted for (PVAF). The eigenvalue is regarded as a measure of the importance of corresponding dimension in capturing the information provided by the originally observed items. In addition, the total amount of percentage accounted for conveys how well the group of retained dimensions, as a whole, captures the initial set of observed items.

3.13.3 Missing data

The unavoidable component of any empirical information is missing data (Bhattacherjee, 2012). This inconsistency is caused by the respondents who may not provide answers to some of the questions, based on their ambiguity, or due to the fact that they are asked confidential information. Normally, in the research arena, three types of missing data can be found, namely, (a) missing at random (MAR), (b) missing not at random (MNAR) and (c) missing completely at random (MCAR) (Croninger & Douglas, 2005). It is well figured out that, in a large-scale study like TIMSS, the datasets tend to include all of these kinds of missing information. The missing data includes the number of categorical as well as continuous numerical variables. The missing data unique codes used in the TIMSS study were as follows: (i) omitted, (ii) not administered and (iii) don’t know responses.

There is a variety of the procedures that may be utilised to check and analyse the missing data. In the SPSS package there are two methods that are designed specifically to deal with the missing data, namely the listwise method and the pairwise method. The former is used to remove any case that has missing values and the outcomes results in a loss of sample (International Business Machine Corporation, 2012). The pairwise method manipulates all the data available in an estimation method such as Full-Information Maximum Likelihood, which is considered superior when missing data is non-random (IBM, 2012).

The CATPCA method has a built in technique that manages the missing data (IBM, 2012). It should be noted that in this study, missing data are handled passively as stipulated for each item, which suggests that in optimising the quantifications of a variable, only subjects with valid values on the item are included which contribute to the solution (Theunissen et al., 2003).

3.13.4 Orthogonal factor rotation

It should be taken into cognisance that, even though factors were obtained as pronounced based on the recommended processes, they were still arbitrary. It was therefore important to use a factor rotation, because it provides the researcher with a picture of the similarities among the items in a simpler and clearer format (Barrett, 2007). Numerous data rotational approaches are accessible to an investigator interested in making use of factor analysis techniques (Asparouhov & Muthén, 2009). Verimax and Promax are some of the prominent and commonly used methods; however in this study orthogonal procrustes rotation is used. Orthogonal procrustes rotation is a technique used to rotate a comparison matrix to be similar with a target matrix, minimising the sum of squared differences before similarity is calculated between the two matrixes (Cohen & Manion, 2007).

According to Borg and Groenen (1997) orthogonal procrustes rotation is considered as one of the valuable matching techniques that can be used to swivel and decode two or more similar, or dissimilar matrices. The relationship between two or more matrices of factor loadings is maximized as a consequence of the procrustes rotation assumptions (Ten Berge, 1977). This means, for example, that responses which are based on new information are fitted to factors which are grounded on old data, to serve as targets (Barrett, 2007).

The orthogonal rotation technique is employed to identify factor loadings, and draw a meaningful and understandable factor structure (Barrett, 2007; Cohen & Manion, 2007). The rotation method used in this research had an impact on some of the variations while others did not provide a result in any meaningful way, regardless of the modifications (Briggs & Cheek, 1986). The Orthosim program was utilised to orthogonally rotate the factor loadings extracted, as soon as the CATPCA technique was utilised. In this research study, the procrustean rotation method was used to rotate the component loadings of South Africa to be similar to the component loadings of each of the countries with lower and higher GDP that it was compared to.

3.13.5 Tucker congruent coefficient

In this study, the Tucker congruent coefficients were computed to determine the similarity between South Africa and each of the countries selected in this investigation. The Tucker congruent coefficient is regarded as the most popular instrument suggested by Burt (1948) to compare factors. The Tucker congruent coefficient is an index that ranges from - 1.0 to + 1.0 and it indicates to what extent two paired sets of matrixes are identical (Salkind, 2010).

SPSS was used to compute component loadings using the learners' data based on their teachers' responses. The SPSS-to-Orthosim version 1.3 software was used to convert the SPSS output files into the Orthosim format. Lastly, the Orthosim version 2.1 program was used to calculate the congruent coefficient between South Africa and each of the countries used in this study. It should be noted that the Orthosim software can be used when a researcher is interested in comparing a matrix of factor loadings or multidimensional scaling (MDS) coordinates. The Orthosim software is used to compare factor loadings when the same variables have been used in both analyses. The program is used to calculate the similarity coefficient between a target and comparison matrix.

The congruent coefficient is calculated after the responses from the comparison matrix have been orthogonally rotated against the responses from the target matrix. The software permits an investigator to choose between two types of approaches to the problem, namely "procrustes" and a “non-procrustes” (Barrett, 2007). The “non-procrustes” approach, is used when the comparison and target matrices remain unadjusted and the “procrustes” when the comparison matrix is rotated against the target (Barrett, 2007). The component loadings of South Africa were used as the target matrix while all the countries compared as comparison matrixes. The comparisons were done based on the three predictor variables, namely computer activities, teaching strategies and content coverage.

The Tucker congruent coefficient is computed after one of the factor loading matrices has been transformed to fit a different loading matrix in the least squares sense by a procrustes rotation (Tucker, 1951). There are a number of studies that have been conducted using the congruent coefficient. It is imperative to take a cursory look at the recommendations made by numerous researchers about the congruent coefficient. Some recommendations on interpreting the congruent coefficient, are as follows:

- Mulaik (1972) recommends that, if the congruent coefficient is 0.85 or greater, then there is similarity between the factors;
- Eysenck and Eysenck (1982) stated that a congruent coefficient of 0.95 and above indicates that the factors are identical;
- Barret (1986) recommends that if the congruent coefficient is 0.80 and above there is conceptual similarity;
- Ten Berge (1986) recommends that if the congruent coefficient is 0.85 and above, then there is similarity between the factors;
- For Haven and ten Berge (1977) the most common congruent coefficient cut-off value is 0.85;
- Van der Vijver and Leung (1997) recommend 0.90 as the lowest bound of similarity between factors; and
- Lorenzo-Seva and ten Berge (2006) posit that a value in the range from 0.85 to 0.94 corresponds to fair similarity, while a value greater than 0.95 indicates that the two factors can be considered equal.

For the purpose of this study the Lorenzo-Seva and ten Berge (2006) threshold has been adopted and used to determine similarities between South Africa and its international counterparts. Figure 3:3 indicates the dashboard used in this research to determine the similarity of the component loadings between South Africa and each of its international counterparts.

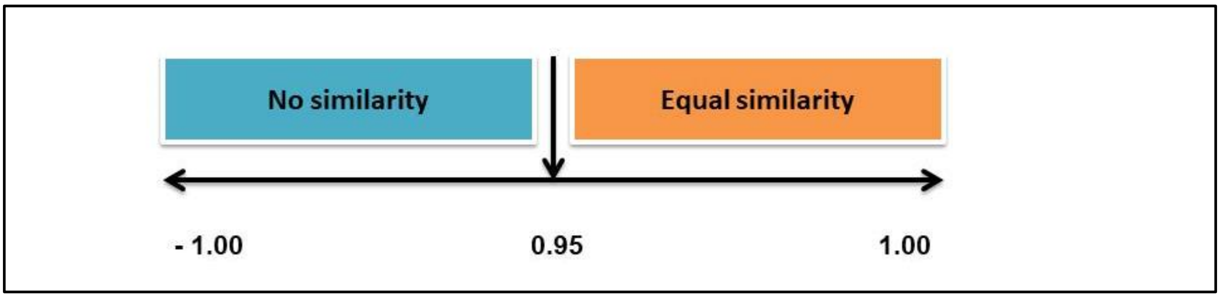

Figure 3:3 Dashboard used to determine similarity between component loadings[1]

Figure 3:3 indicates that there are two segments that are used to determine the similarity about how learners in South Africa compare with their selected international counterparts according to their teachers' viewpoints. It should be noted that:

a) If Ø < 0.95, then it can be construed that there were **no significant similarities** between South African learners and their selected international counterparts with regards to teaching strategies, use of computer activities and specific mathematics content coverage, respectively.

b) If Ø ≥ 0.95 then, it can deduced that there were **significant similarities** between South African learners and their selected international counterparts with regards to teaching strategies, use of computer activities and specific mathematics content coverage, respectively.

3.14 Ethical considerations

According to Cohen and Manion (2007, p. 58) ethical considerations encompass the entire research process. It includes the "appropriateness of research topic, research design, methods, confidentiality, analysis and dissemination of findings must be

[1] If the congruent coefficient is equal to 0.95, then there is significant similarity between the two countries

negotiated with relative openness, sensitivity, honesty, accuracy and scientific impartiality”. Furthermore, Greener (2008, p. 40) attested that ethics are related to “moral choices affecting decisions and standards and behaviour”.

This implies that the educational researchers should be cautious in working with children and other populations that are at risk. It should be noted that ethical consideration has become the basis for conducting an effective and a significant research study (Drew, Hardman, & Hosp, 2007).

According to various writers (Cohen & Manion, 2007; Mertens, 1998; Saunders et al., 2009) the major responsibilities that a researcher should take into cognisance when conducting a research study are to:

- obtain informed consent from the participants;
- protect participants from harm;
- ensure their facelessness and confidentiality;
- ensure that the information collected will not be misused from the interested party in a way that could affect the participants.

In a nutshell, ethics considerations can be regarded as the beliefs and procedures that guide the researchers to uphold the things a group of people value (Yin, 2011). It should be noted that, before the commencement of the TIMSS 2011 study, the IEA and the NRC requested consent from the individual Ministries of Education, from the schools and other stakeholders, to collect and publish statistics after the analysis, from all the participating countries. As such, the researcher did not need to obtain consent from the individual participants. The information analysed in this study was taken from the TIMSS website that is available in the public domain (Foy et al., 2011). The names of schools, learners and teachers that participated in the original study were not stated in the report, and the ethical value of the original study has been conformed to. The Ethics Committee of the Faculty of Education also approved this study (see Ethics clearance certificate, p. ii).

3.15 Closure

This chapter discussed the research paradigm, methodology and approaches subscribed to in this study, as well as the research strategy, data gathering instruments, and the methods used. Validity issues were also discussed. The aim of the discussions was to clarify the methodology assumptions that were utilised in this study. In this research the post-positivist paradigm was used as the underlying assumption that underpins the researcher's worldview. Furthermore, the main research questions that formed the basis of this study were also discussed.

CHAPTER 4: FACTOR ANALYSIS AND DESCRIPTIVE STATISTICS FINDINGS

4.1 Introduction

This chapter commences with the presentation of the framework that was employed to select the countries analysed in this study. The descriptive statistics are outlined encompassing the population and the sample of schools. Furthermore, the numbers of learners are delineated based on the teachers' age, gender, as well as their main educational qualification.

Then, in a more detailed manner, three countries with higher, and three countries with lower government expenditure on education than South Africa, are investigated, to provide a comparison between them and South Africa. Section 4.2 gives a detailed explanation to why only three countries with higher and three countries with lower government expenditure on education were considered. Through the comparison, the researcher is hoping to provide insights in terms of areas of improvement where South Africa is lagging behind.

4.2 Descriptive statistics

The initial step in data analysis is to use descriptive statistics as they permit the researcher to describe data using a number of indices (Field, 2009, p. 141). The descriptive statistics calculated in this study are frequencies. Furthermore, graphs are used to display the frequencies. Statistical figures, as well as graphs, are used to describe the sample of learners emanating from the teachers' responses about their biographical information, major areas of study related to mathematics and education mathematics, the use of computers and the provisioning of mathematics resources to learners.

The descriptive statistics were calculated by using the percentages of learners taught by teachers who filled out the teachers' questionnaire, rather than by the percentages of teachers selected in each country.

Figure 4:1 depicts the structure that was used as a roadmap for the descriptive data analysis.

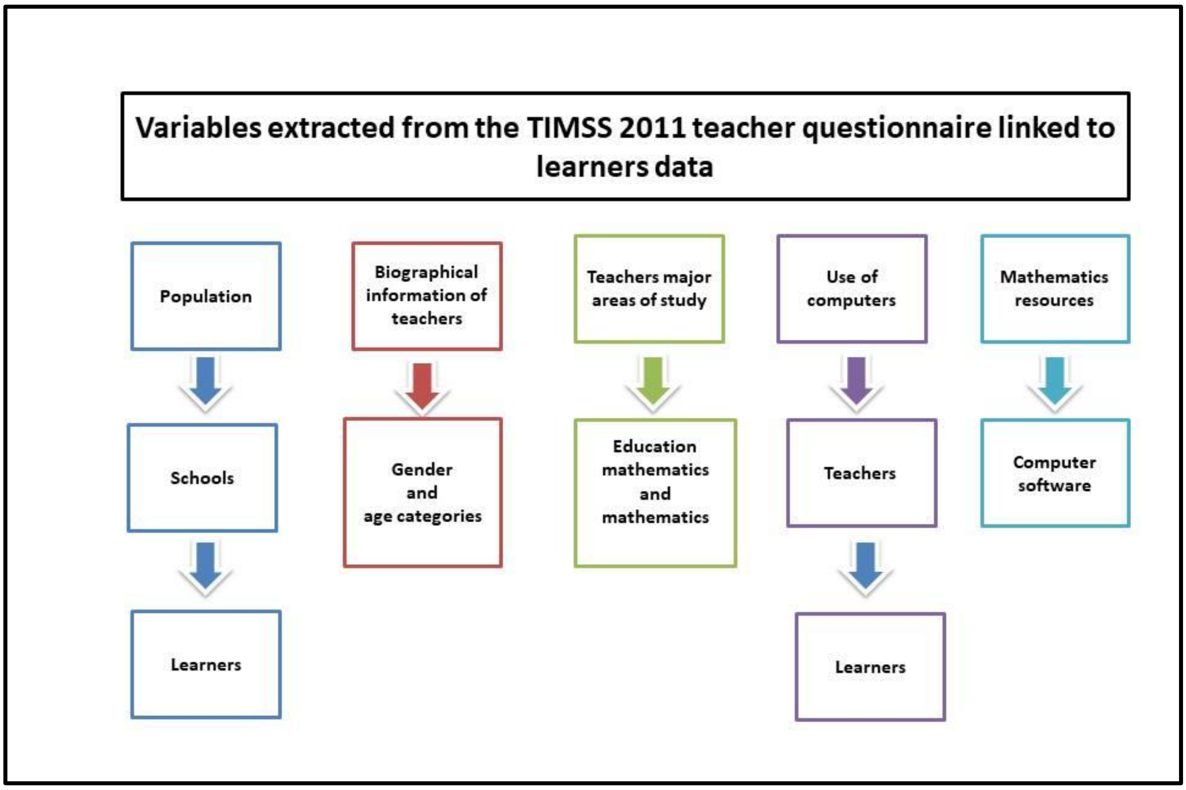

Figure 4:1 Structure of the descriptive statistics

It should be noted that the selected countries were arranged according to the two distinct groups, namely, countries with lower and countries with higher government expenditure on education than that of South Africa.

4.3 Descriptive statistics used in the study

The purpose of this study was to draw a comparison between South African learners and six of their international counterparts that participated in the TIMSS 2011 study. The selection of the questions analysed in this study was based on the TPACK framework. The variables used in this study were reported in terms of the number of learners who were taught by teachers who completed the teachers' questionnaire. The following variables were selected from the TIMSS 2011 Grade 8 Mathematics Teacher Questionnaire (MTQ):

- **Population** – The number of schools and learners sampled in this study.

- **Biographical information of teachers -** Age and gender distribution of the teachers who taught the learners.
- **Teachers major areas of study -** Mathematics or educational mathematics as the teachers' major areas of study.
- **Use of computers -** The teachers' use of computers for administration, lesson preparation and classroom instruction.
- **Use of computer activities** – Learner's use of computer activities.
- **Provision of mathematics resources -** Use of relevant computer software.

4.4 Population and sampled schools

In this section the population of schools, as well as the sampled schools used in the study, are described.

4.4.1 Population and sampled schools

Table 4:1 shows the population and the number of sampled schools from each of the seven countries that were analysed in this study.

Table 4:1 Population and samples schools

Government expenditure on education	Countries names	Population of schools	Sampled Schools	Difference
Higher	Norway	1 162	134	16
	Sweden	1 519	153	3
	Saudi Arabia	6 395	153	3
	South Africa	9 504	285	135
Lower	Thailand	10 210	172	22
	Singapore	715	145	5
	United Arab Emirates	596	458	308
	Total	**30 101**	**1500**	

A sample population of 30 101 schools was used during this study, 9 076 schools from countries with higher and 11 521 from countries with lower government expenditure on education than South Africa. The population size of sampled schools in South Africa was higher than most of the countries analysed in this study. In contrast, the population of schools in South Africa was lower than their counterparts in Thailand (10 210). United Arab Emirates had the highest number of school sampled (458) because of the lowest number of teacher-learner ratio.

It should be noted that TIMSS required that 150 schools be sampled in each country. The difference between the number of schools sampled, and the TIMSS requirement of 150 schools per country, is also shown. It is interesting to note that the number of sampled schools in Norway (134) and Singapore (145) was lower than the TIMSS minimum requirements of 150 schools. It is imperative to note from the results that the sampled population of schools in Norway and Singapore were lower than the TIMSS sampling strategy of 150 schools for each target grade. This was due to the fact that these countries had more than 4 000 learners as stipulated by the TIMSS sampling strategy.

4.4.2 Number of learners used in this study

Table 4:2 shows the number of learners sampled from each of the seven countries that were analysed in this study.

Table 4:2 Number of learners used in this study

Government expenditure on education	Countries' names	Number of learners		
		Sampled population	Missing	Used
Higher	Norway	3 972	94	3 878
	Sweden	5 816	1 061	4 755
	Saudi Arabia	4 344	67	4 277
	South Africa	11 969	857	11 112
Lower	Thailand	6 124	0	6 124
	Singapore	5 927	35	5 892
	United Arab Emirates	14 469	1 027	13 442
	Total	52 621	3 141	49 480

A sample population of 52 621 learners were used during this study, 12 910 learners from countries with higher and 25 458 learners from countries with lower government expenditure on education than South Africa. Furthermore, the population size of sampled learners in United Arab Emirates was higher than all the countries analysed in this study.

4.5 Biographical information

This section describes the biographical information of learners based on their teachers' responses from the countries with higher and lower government expenditure on education than that of South Africa, as it was analysed in the current study. It is important to note that TIMSS requires researchers to report teachers' data in terms of the number of learners who were taught by teachers with a specific characteristic. The biographical information refers to gender, as well as the age categories of the mathematics teachers who taught the learners that were sampled by TIMSS.

4.5.1 Learners distribution per teachers' gender categories

This section shows the distribution of learners according to the gender categories of their mathematics teachers. Countries with a higher government expenditure on education than South Africa are considered first and then followed by countries with a lower government spending on education than South Africa (Annexure G).

Figure 4:2 shows the distribution of learners according to gender categories of teachers from countries with **higher government expenditure on education** than that of South Africa.

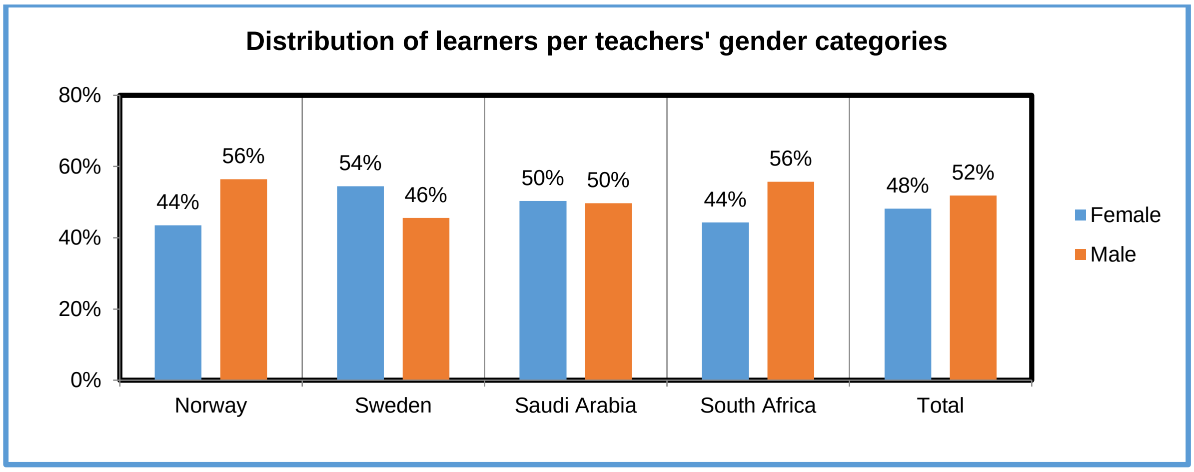

Figure 4:2 Learners distribution per teachers' gender categories from countries with higher government expenditure on education

In the countries with higher government expenditure on education the majority of learners were taught by male teachers, contributing up to 52% of total respondents. In South Africa, more learners were taught by male teachers (56%) than was the case in Saudi Arabia (50%) and Sweden (46%). In contrast, a different pattern was found between learners in South Africa and their international counterparts in Sweden where 54% of them were taught by female teachers.

Figure 4:3 shows the distribution of learners according to gender categories of teachers from countries with **lower government expenditure on education** than that of South Africa.

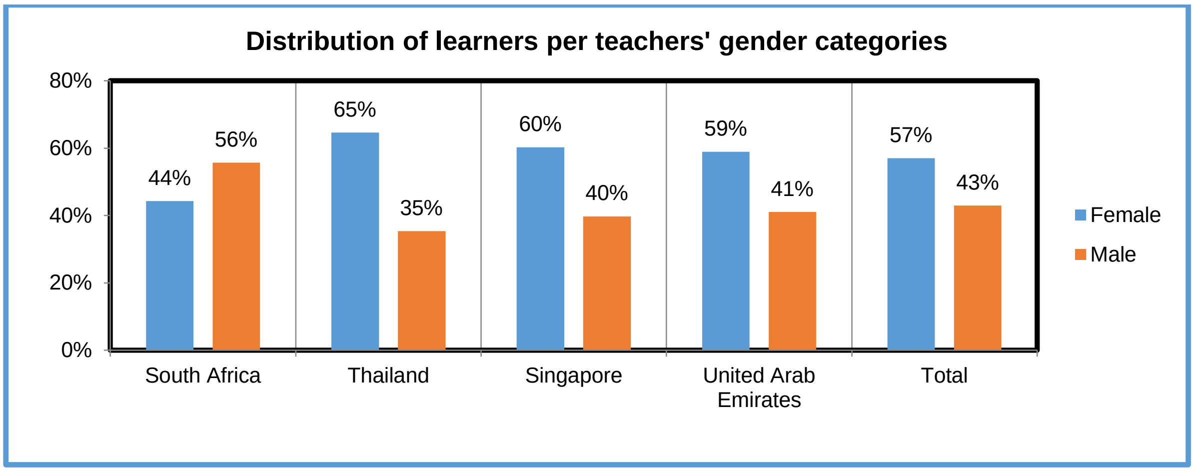

Figure 4:3 Learners distribution per teachers' gender categories from countries with lower government expenditure on education

In this category, the majority of learners was taught by female teachers, contributing up to 57% of the total number of respondents. In South Africa, the majority of learners was taught by male teachers which is the opposite of that of the other countries. Figure 4:4 shows that the majority of learners was taught by female teachers.

4.5.2 Learners distributions per different teachers' age categories

This section shows the distribution of learners according to the age categories of mathematics teachers in countries with higher and lower government expenditure on education analysed in this study. Figure 4:4 shows the distribution of learners according to gender categories of teachers from countries with **higher government expenditure on education** than that of South Africa.

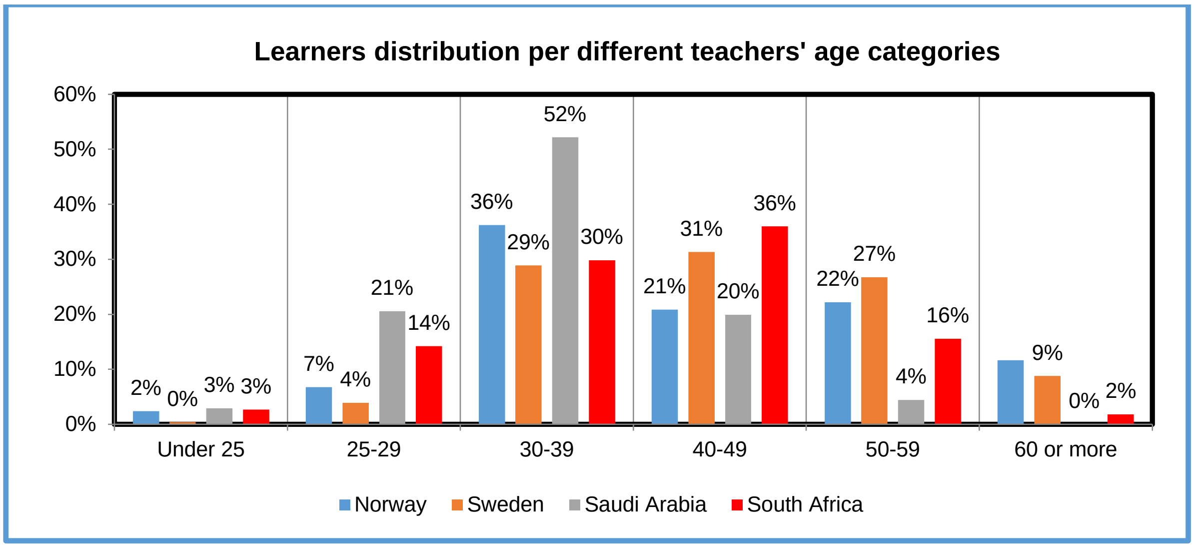

Figure 4:4 Learners distributions per different teachers' age categories from countries with higher government expenditure on education

In all the countries depicted here the lowest numbers of learners were taught by mathematics teachers under the age of 25, and in the category 60 or above. The majority of the learners from the countries with higher government expenditure on education was taught by teachers between the ages of 30 and 49.

Figure 4:5 shows the distribution of learners according to the gender categories of teachers from countries with **lower government expenditure on education** than that of South Africa.

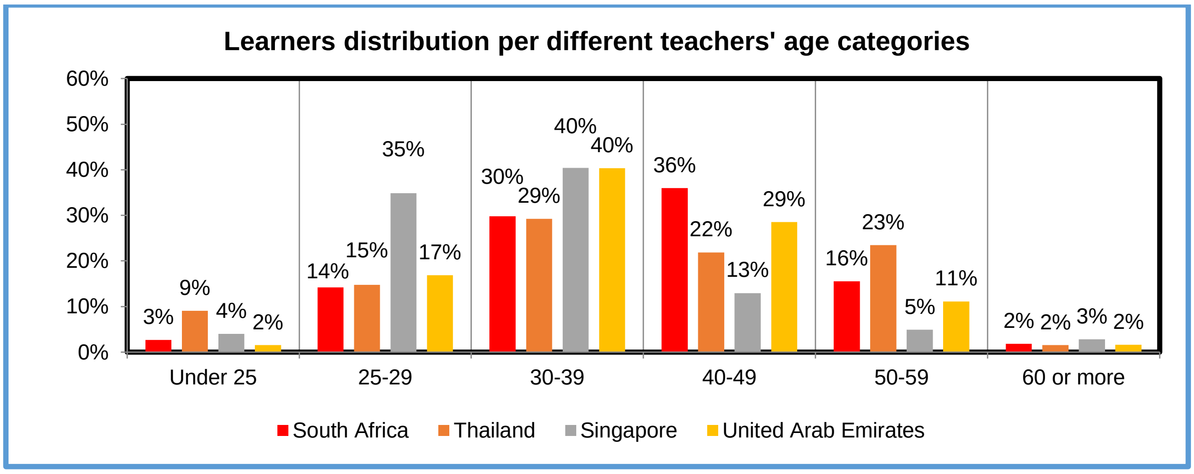

Figure 4:5 Learners distributions per different teachers' age categories from countries with lower government expenditure on education

The results revealed that the lowest number of learners in South Africa and their international counterparts were once more taught by mathematics teachers who were under 25, and over 60 years of age. Whilst the majority of the learners was taught by teachers between the ages of 30 and 49, it was interesting to note that in Singapore a large proportion of the teachers were younger, with 35% of the learners taught by teachers who were between the ages of 25 and 29. Since the Singapore learners outperformed all other countries in the TIMSS 2011, these phenomena may be something to explore in more depth in future studies.

4.6 Major areas of study in relation to mathematics

This section presents the results based on the analysis of the learners taught by teachers who had education mathematics and mathematics respectively, as their major areas of study. It should be noted that TIMSS do not specify exactly what they mean by mathematics and education mathematics and that this may have led to a difference in interpretation between countries, and even between individual teachers who completed the questionnaire (Annexure H).

4.6.1 Education mathematics as the main area of study

Figure 4:6 shows the number of learners taught by teachers who had education mathematics as their major area of study in the countries with **higher** and **lower government expenditure on education** than South Africa as analysed in this study.

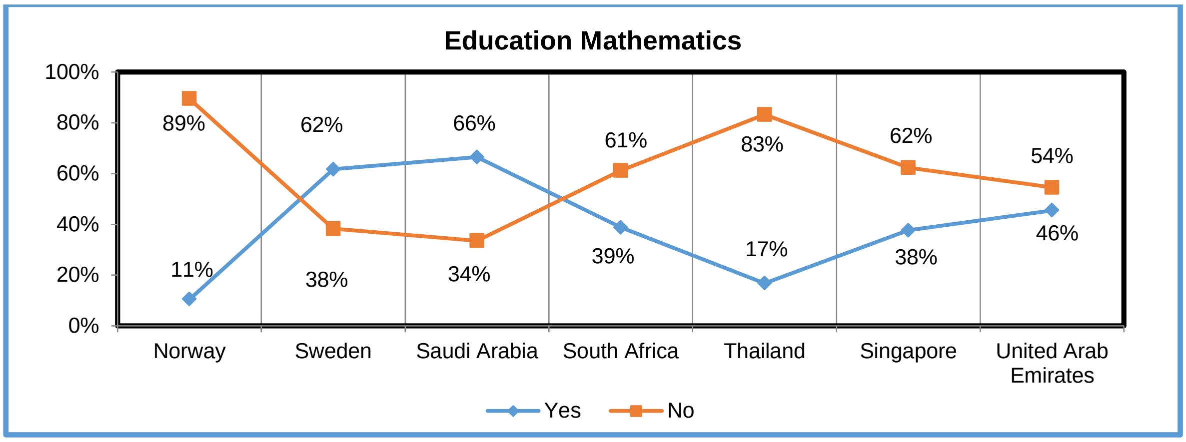

Figure 4:6 Teachers responses about education mathematics

It is remarkable that there were more learners taught by teachers in South Africa who had not studied education mathematics as their major area of study (61%) than those who did (39%). One wonders if the high number of teachers in South Africa, who do not have education mathematics as a major, could possibly be a contributing factor to the country's poor performance in mathematics. This is similar to Norway (89%), Thailand (83%) and Singapore (62%) where the highest number of learners were also taught by teachers who had not studied education mathematics. Learners in these two countries are, however, outperforming their counterparts in South Africa when it comes to mathematics.

Interestingly, there were almost an equal percentage of learners in South Africa and Singapore who were taught by teachers who had education mathematics as their major area of study. Despite this similarity, the learners in Singapore also outperformed their South African counterparts. It is thus obvious that there are other factors impacting on the successful teaching of mathematics in Singapore that may be worthwhile to explore in more detail.

In order to improve mathematics performance of learners in South Africa, higher education institutions may want to reconsider the curriculum design of degree programmes that are aimed at training mathematic teachers, to explore the differences between the mathematics performance of learners with regards to the nature of the major area of study of their teachers.

4.6.2 Mathematics as the main area of study

Figure 4:7 shows the number of learners taught by teachers who had mathematics as their major area of study in the countries with **higher** and **lower government expenditure on education** than South Africa, as analysed in this study.

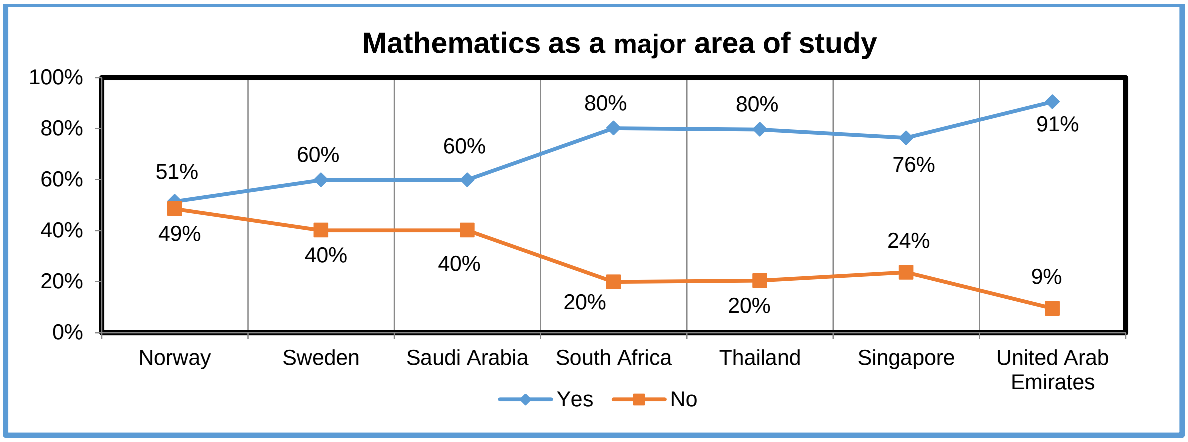

Figure 4:7 Teachers responses about mathematics as their major area of study

It is interesting to note that mathematics seem to be the major area of study for the majority of the respondents in all of the countries. It would make sense that having a teacher with a solid background in the pure discipline of mathematics would give the learners in their class an advantage. Since all the learners in all six the countries in this study, had outperformed the South African learners, it may be an indication of the value that a teacher's subject discipline and knowledge have on the performance of their learners.

As there are many unanswered questions regarding the way in which the participants interpreted the question about their major area of study, these findings are likely to be inconclusive. It would be of value, though, to pursue the role that a teacher's major area of study plays in the academic performance of their students in more detail in a future study.

4.7 Use of computers by mathematics teachers

This section provides the results based on the analysis of the learners taught by teachers who reported that they used computers for lesson preparation, administration and instruction, respectively (Annexure I).

4.7.1 The use of computers for lesson preparation

Figure 4:8 shows the distribution of learners according to mathematics teachers who indicated that they have used computers for **lesson preparation**.

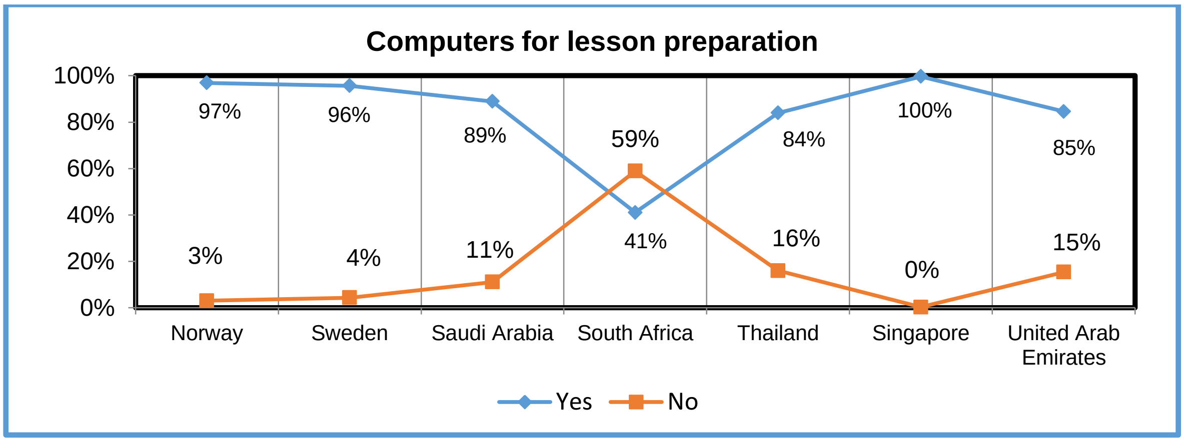

Figure 4:8 Computers for lesson preparation

The findings from the analysis revealed that only 41% of the learners in South Africa were taught by teachers who used computers for their lesson preparation. This is in strong contrast with the data obtained for all the other countries in the study, namely Thailand (84%), United Arab Emirates (85%), Saudi Arabia (89%), Sweden (97%), Norway (97%) and Singapore (100%). In countries with both higher and lower government expenditure on education than that of South Africa, the difference between those learners taught by teachers who used computers in their lesson preparation and those who did not, was immense.

It can be deduced from the results that the majority of the teachers in the countries in the study regarded computers as a tool for lesson preparation. It is also known that in all of these countries, the learners outperformed their South African counterparts in terms of the mathematics performance. Whilst one cannot deduce that there is a direct causal effect between the use of computers for preparation purposes and learner performance, the stark difference between South African teachers' use of computers for planning purposes and the rest of the sampled countries, merits further investigation.

4.7.2 The use of computers for administration

Figure 4:9 shows the distribution of learners taught by teachers who used computers for **administration** in the countries with higher and lower government expenditure on education than that of South Africa.

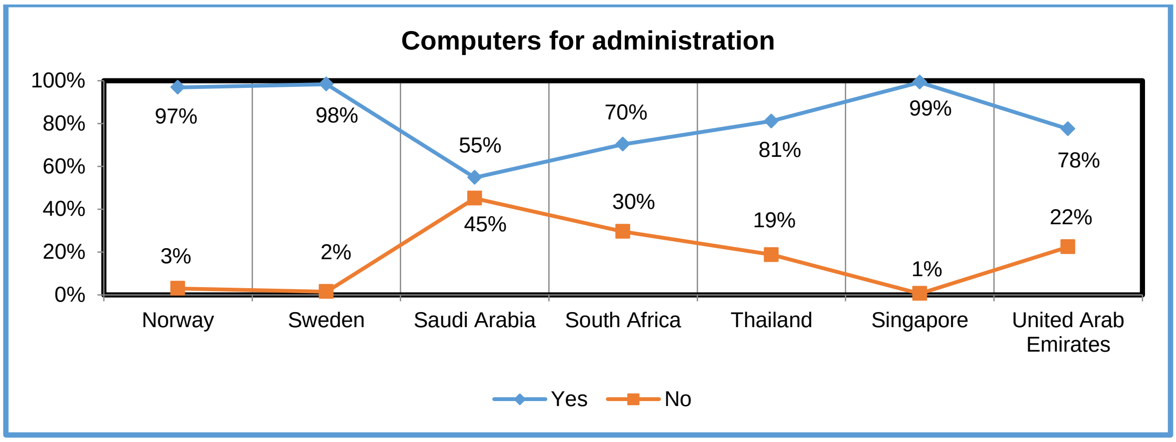

Figure 4:9 Use of computers for administration

The results revealed that 70% of the learners in South Africa were taught by teachers who used computers for administration. This result is much lower than, for example, in Singapore where almost all their learners (99%) were taught by teachers who indicated that they use computers for administrative purposes. The difference is worthy of further investigation, as Singapore learners performed the best out of all the students who participated in TIMSS 2011.

Whilst it is promising that teachers in South Africa are seemingly starting to use computers for administrative tasks, it is still in stark contrast with countries like Singapore (99%), Sweden (98%), Norway (96%), Thailand (85%) and the United Arab Emirates (75%) where a significant number of teachers seem to already use computers for this purpose. South Africa (30%) and Saudi Arabia (45%) are the only ones where a rather high number of teachers reported that they do not yet use computers for administration.

Teachers in these countries could be encouraged to use computers for their administrative work such as the capturing of marks and producing learners' performance reports. Further research is needed to find out how teachers' use of computers for administrative purposes relates to their teaching effectiveness, and ultimately their learners' performance in the mathematics classroom.

4.7.3 The use of computers for instruction

Figure 4:10 shows the percentages of learners who are taught by teachers who use computers for **classroom instruction** in the countries with higher and lower government expenditure on education than that of South Africa.

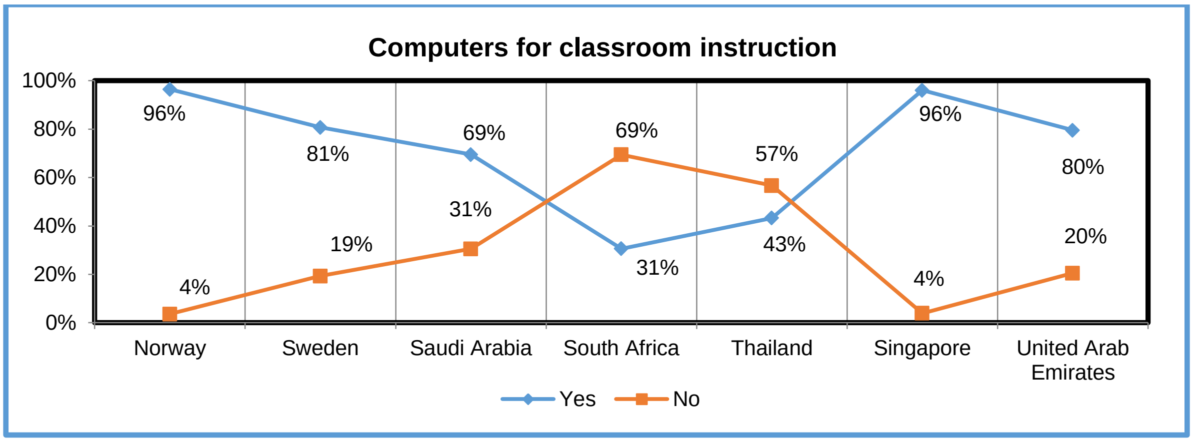

Figure 4:10 Teachers' use of computers for classroom instruction

From Figure 4:10 it is obvious that South Africa was lagging behind in terms of the number of learners (31%) who were taught by teachers who use computers for classroom instruction. Other than for Thailand (with 43%), all the other countries seem to use computers for classroom instruction. The differences in the results between South Africa and both Norway (96%) and Singapore (96%) is once again considerable and therefore merits further investigation.

It is imperative that South African teachers should be empowered in the use of computers for planning, administrative and teaching purposes and that teachers should be provided with the necessary training on how computers can be integrated into teaching and learning. Whilst this result is not an indication of a direct relationship between the use of computers for these purposes and the mathematical performance of their learners, the relationship is nonetheless thought-provoking.

4.8 Use of computer activities by learners

This section indicates the percentage of learners who have used computer activities to explore mathematical principles and concepts, practise skills and procedures, look up ideas and information, as well as process and analyse data.

4.8.1 Explore mathematical principles and concepts

Figure 4:11 shows the percentage of learners in countries with **higher government expenditure on education** than South Africa whose teachers indicated that they use computer activities to **explore mathematical principles and concepts**.

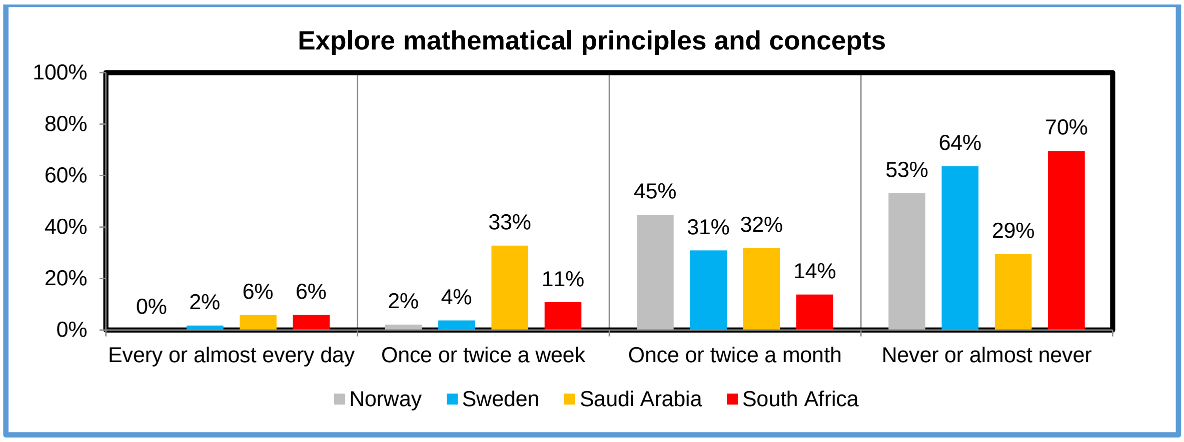

Figure 4:11 Use of computer activities to explore mathematical principles and concepts from countries with higher government expenditure on education than South Africa

It seems as if very few of the teachers in countries with higher government expenditure on education asked their learners to explore mathematical principles and concepts using computers on a daily basis. Instead, with the exception of Saudi Arabia, the majority did not ever require their learners to do so. There seems to be a tendency in Saudi Arabia (32%), Sweden (31%) and Norway (45%) to use computers to encourage learners to explore principles and concepts at least once or twice a month, however, this trend is lagging in South Africa (14%).

Figure 4:12 shows the percentage of learners in countries with a **lower government expenditure on education** than South Africa whose teachers indicated that they use computer activities to **explore mathematical principles and concepts**.

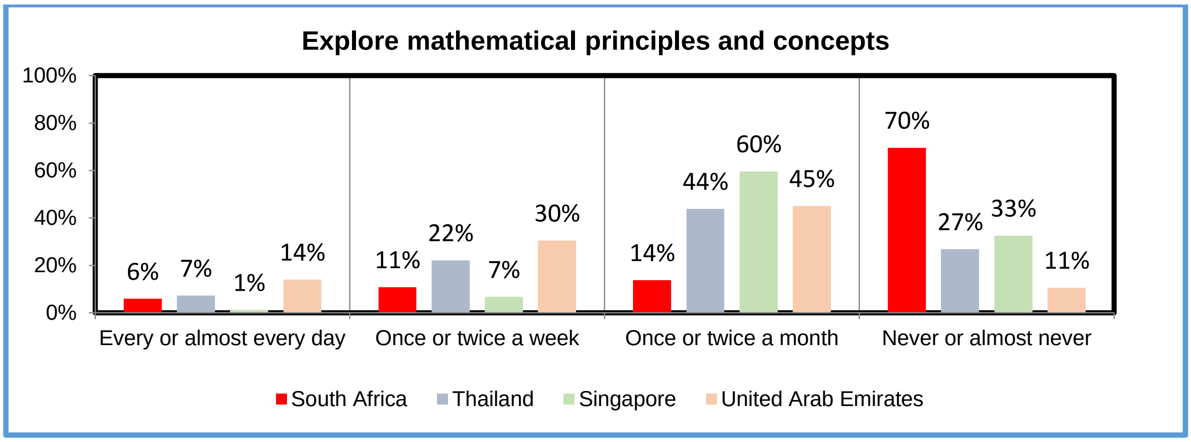

Figure 4:12 Use of computer activities to explore mathematical principles and concepts from countries with lower government expenditure on education than South Africa

South Africa seems to be lagging with respect to using computers to explore principles and concepts when compared to the lower **government expenditure on education** countries. A large percentage of learners (70%) in South Africa indicated that their teachers have "*never or almost never*" asked them to use computer activities to explore mathematical principles and concepts. This is in contrast with the other lower **government expenditure on education** countries where teachers do seem to encourage computer activities aimed at exploring mathematical principles and concepts, at least once or twice a month. It is clear from the results that teachers in South Africa are not yet integrating computer activities into their teaching and learning activities on a daily basis.

4.8.2 Practise skills and procedures

Figure 4:13 shows the percentages of learners in countries with **higher government expenditure on education** who were allowed to use computer activities to **practise skills and procedures.**

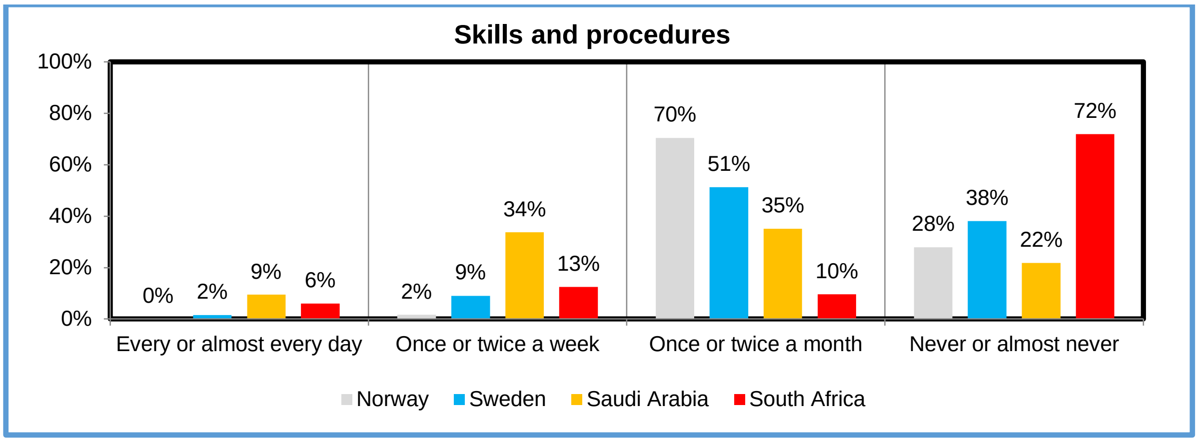

Figure 4:13 Use of computer activities to practise skills and procedures from countries with higher government expenditure on education than South Africa

In a subject such as mathematics, one would expect teachers to encourage their learners to use computers to practise skills and procedures due to the fact that computers are particularly good for drill and practise kind of activities. It is, therefore, interesting to note that very few of the learners were exposed to this kind of computer activity on a daily, or even weekly basis.

There were minimal differences between learners in South Africa and their international counterparts in countries with higher government expenditure on education whose teachers indicated that they have used computer activities to practise skills and procedures *"every or almost every day"*. However, the percentage for South Africa differs rather significantly from the international counterparts in the section "*never or almost never*" showing that computers are used more regularly in countries with higher **government expenditure on education** than is the case in South Africa. This difference is also clear in the section where teachers indicated that they requested their learners to use computers to practise skills and procedure "*once or twice a month".* Only 10% of the learners in South Africa are taught in this way, where the other countries, and particularly Norway (70%) seem to use computers on a monthly basis.

Figure 4:14 shows the percentages of learners in countries with **lower government expenditure on education** than South Africa whose teachers use computer activities to **practise skills and procedures.**

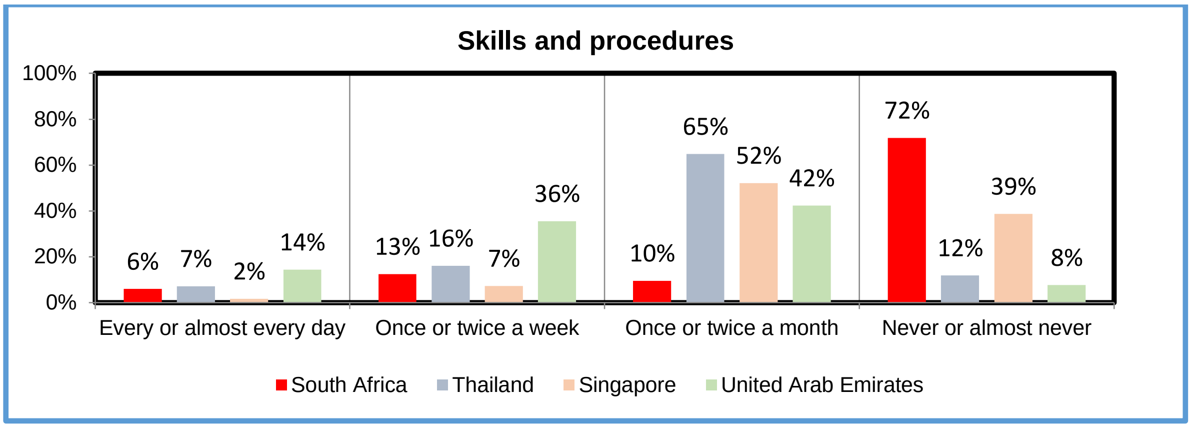

Figure 4:14 Use of computer activities to practise skills and procedures from countries with lower government expenditure on education that South Africa

It is evident from the results that learners in South Africa and their international counterparts were not given the same kind of exposure with regards to the use of computers to practise skills and procedure. This gap between South Africa and the countries with lower **government expenditure on education** is particularly clear in the "*once or twice a month*" and "*never or almost never*" where 72% of the teachers indicated that they never, or almost never, use computers to practise skills and procedures. The limited use of computer to practise skills and procedures should be further investigated in order to determine why the uptake is so slow in South Africa.

4.8.3 Look up ideas and information

Figure 4:15 shows the teachers' responses about whether or not learners in countries with **higher government expenditure on education** than South Africa use computer activities to **look up ideas and information** during mathematics lessons.

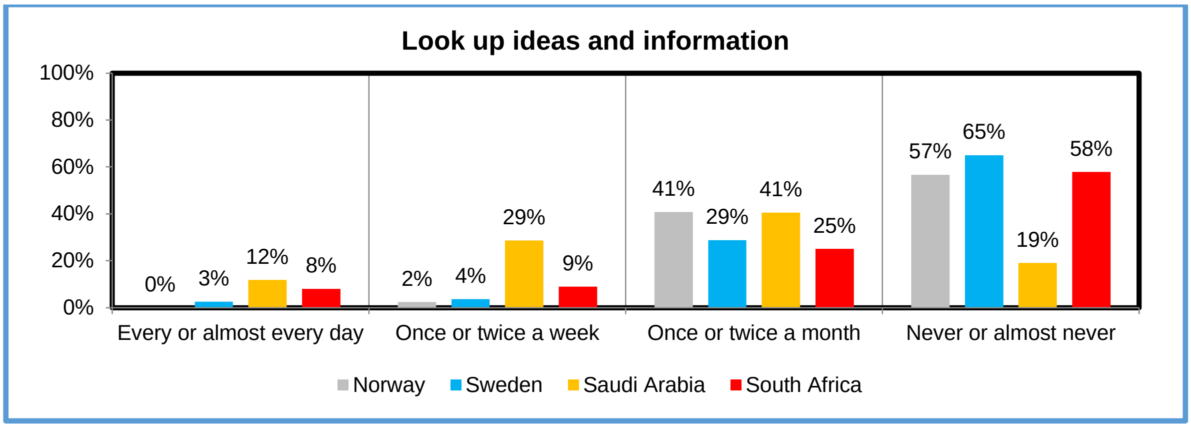

Figure 4:15 Use of computer activities to look up ideas and information from countries with higher government expenditure on education than South Africa

The results reveal that whilst the percentage of South African learners (25%) who use computers to look up ideas and information is still less than for its counterparts in countries with higher **government expenditure on education**, it seems more on par than with other computer-related activities that were explored through the TIMSS questionnaire. This result may be because the notion of "*looking up ideas and information*" is not popular in the field of mathematics, or it may be that teachers did not have a clear understanding with regards to what this kind of activity would entail in a mathematics classroom.

Figure 4:16 shows the percentages of learners in countries with **lower government expenditure on education** than South Africa whose teachers indicated that they use computer activities to **look up ideas and information** during mathematics lessons.

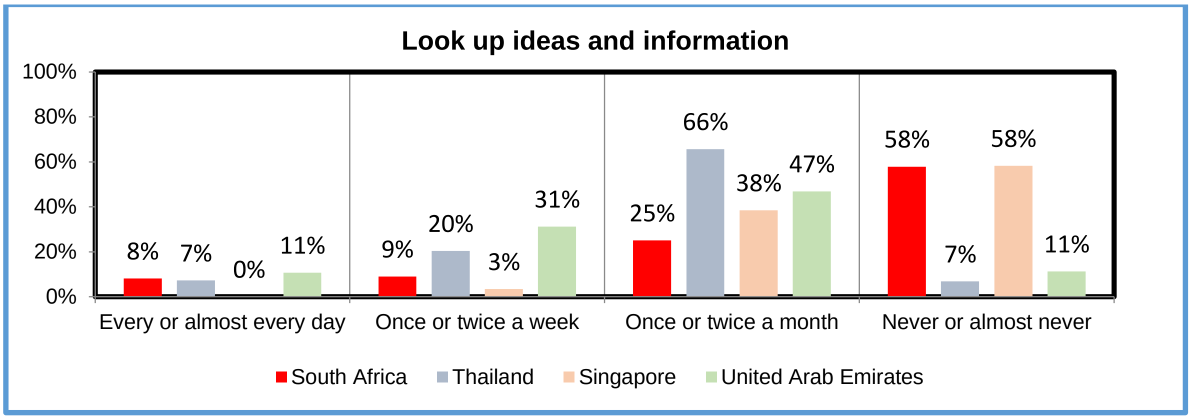

Figure 4:16 Use of computer activities to look up ideas and information from countries with lower government expenditure on education than South Africa

The results reveal that there were minimal differences between learners in South Africa (8%) and their counterparts in Thailand (7%) and United Arab Emirates (11%) who have used computer activities to look up ideas and information "*every or almost every day*".

In contrast, a different pattern was found between learners in South Africa and their counterparts in the "*never or almost never*" category where there was a large difference between South Africa's 58% and the 7% and 8% of Thailand and the United Arab Emirates respectively. It seems that the countries with lower government expenditure on education are all using computers to look up ideas and information more regularly than in South Africa.

4.8.4 Process and analyse data

Figure 4:17 shows the percentages of learners in countries with **higher government expenditure on education** than South Africa whose teachers indicated that they used computer activities to **process and analyse data** in mathematics lessons.

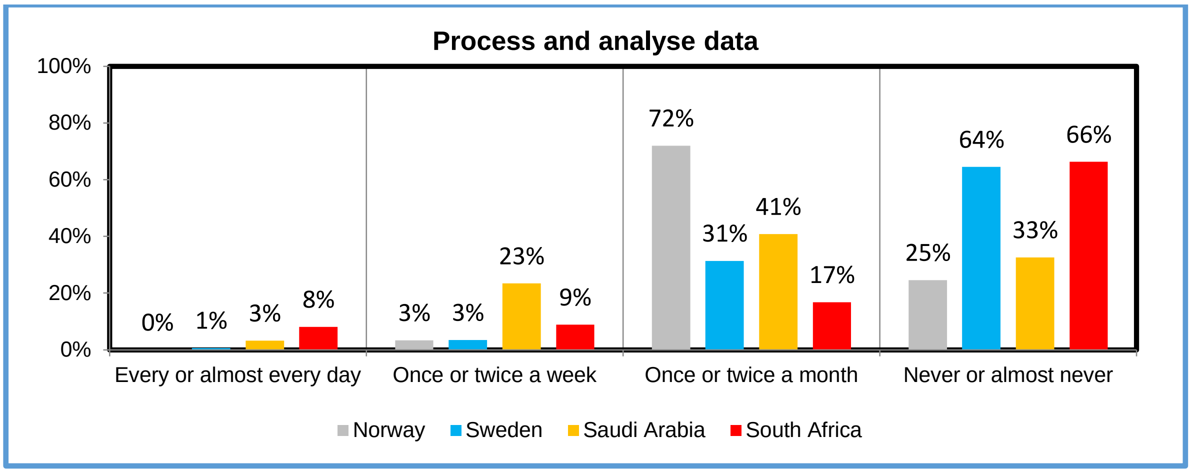

Figure 4:17 Use of computer activities to process and analyse data from countries with higher government expenditure on education than South Africa

The results revealed that only a few learners in South Africa (17%) were taught by teachers who encouraged them to use computers to process and analyse data "*once or twice a month*". This is surprising, since data processing is something that computers are particularly good at and programs, such as Microsoft Excel, lean itself to this kind of processing and analysis. However, the results may be an indication of the mathematics principles taught in the curricula for Grade 8/9 rather than an indication of teachers' unwillingness to use computers for this purpose.

Figure 4:18 shows the percentage of learners in countries with **lower government expenditure on education** than South Africa whose teachers indicated that they used computer activities to **process and analyse data** during mathematics lessons.

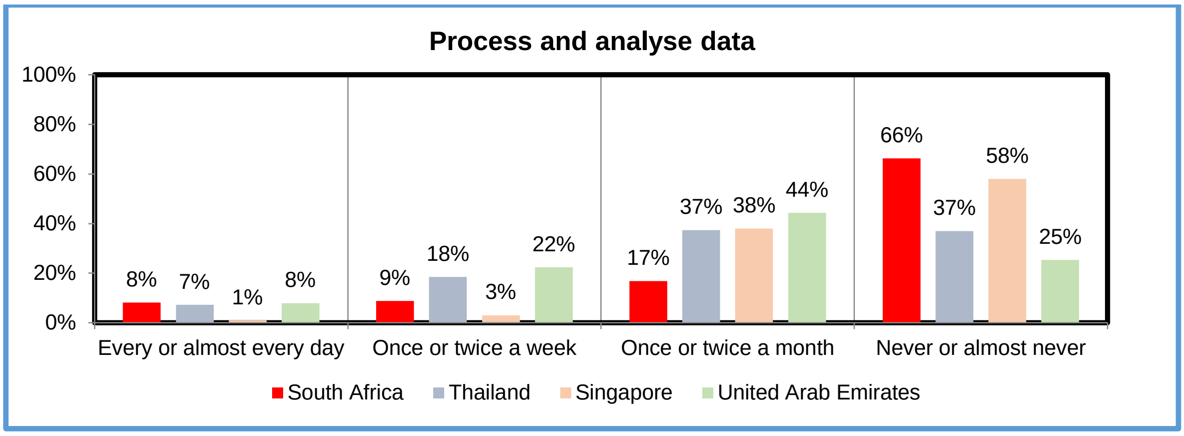

Figure 4:18 Use of computer activities to process and analyse data from countries with lower government expenditure on education than South Africa

The results for countries with lower **government expenditure on education** reveal once again that percentage of learners in South Africa (17%) whose teachers encourage them to use computers to process and analyse data "*once or twice a month*", are the lowest while the majority (38%) of Singapore learners, (who outperformed all their counterparts in the TIMSS 2011 study) used computers for this purpose at least once a month.

4.9 Mathematics resources used by teachers

This section outlines the statistical analysis of the mathematical resources used by learners in countries with higher and lower government expenditure on education than South Africa. These learners were associated with teachers, who indicated that they have used computer software.

4.9.1 The use of computer software

Figure 4:19 shows the percentage of learners from countries with **higher government expenditure on education** than South Africa whose teachers indicated that they **used computer software in their mathematics lessons**.

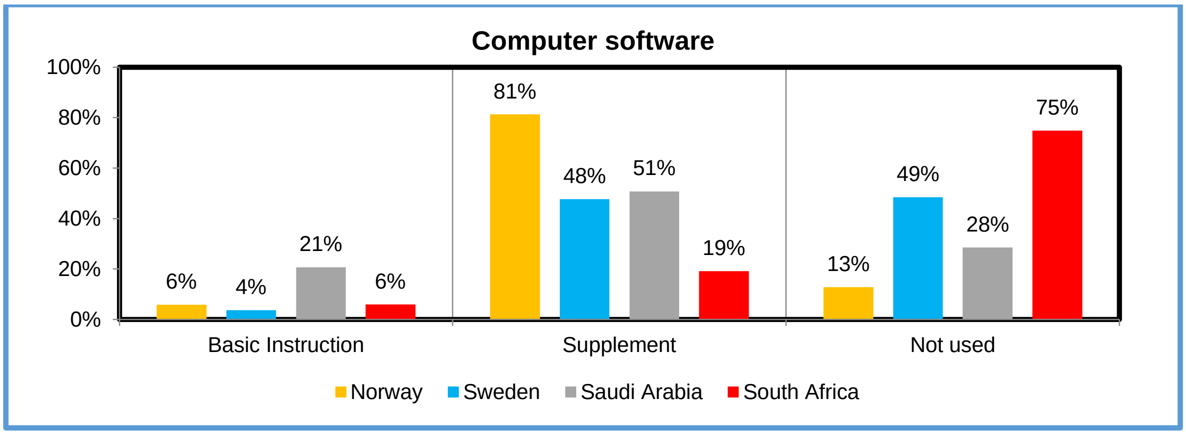

Figure 4:19 Use of computer software in mathematics classroom from countries with higher government expenditure on education than South Africa

The results reveal that there were similarities between learners in South Africa (6%) and their international counterparts in Norway (6%) whose teachers reported that they have used computer software for basic instruction. In contrast, a different pattern was found between learners in South Africa whose teachers indicated that they have utilised computer software as a supplementary resource, and their international counterparts. The biggest difference was found between learners in South Africa (19%) and their peers in Norway (81%) where their teachers indicated that they used computer software as a supplement to normal classroom teaching. With 75% of South African learners not exposed to the use of computer software in their mathematics classrooms, South Africa seems to be lagging behind the rest of the countries in this regard.

Figure 4:20 shows the percentage of learners in countries with **lower government expenditure on education** than South Africa whose teachers indicated that they **used computer software in their mathematics classrooms**.

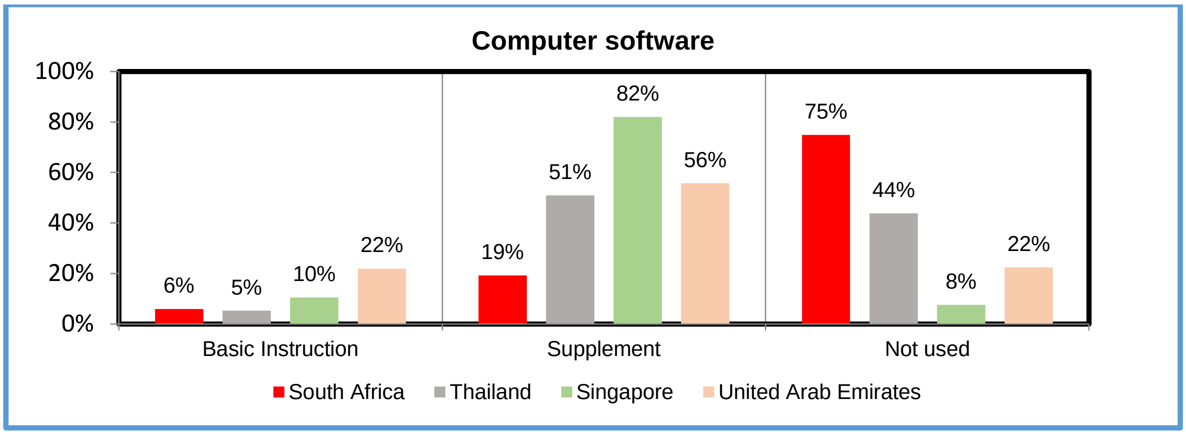

Figure 4:20 Use of computer software in mathematics classroom from countries with lower government expenditure on education than South Africa

It is once again clear that South Africa lags behind when it comes to the use of computer software as our data is showing that we hardly use it for basic instructional purposes, or as a supplement to normal classroom teaching. We also have the highest number of learners who don't use computer software at all when compared to the countries with lower government expenditure on education in the study. It should be noted that the slow progress of providing schools in South Africa with appropriate interactive software for use in schools, might have contributed to these patterns of usage.

4.10 Conclusion

This chapter presented the framework that was used to select the countries that were compared with South Africa. Furthermore, the descriptive statistics were outlined, which entailed the population, sample of schools, age of teachers, gender of teachers, as well as an indication of their main educational qualification. The analysis was based on the distribution of learners according to their mathematics teachers responses during the TIMSS 2011 study.

Chapter 5 will present the inferential statistics and findings based on the three research questions that guided this study. The analysis will also be based on the distribution of learners according their mathematics teachers responses during the TIMSS 2011 study.

CHAPTER 5: ANALYSIS OF THE INFERENTIAL STATISTICS

5.1 Introduction

Chapter 5 presents the analysis and the findings of the study that are grounded in the data that was acquired from the TIMSS 2011 database. The results based on the CATPCA technique, orthogonal procrustean rotation, as well as the Tucker congruent coefficient are presented. The reader should take into consideration that the sampling for the teachers who completed the questionnaire, was based on their participating students. Therefore, in this report the learner is at all times the unit of investigation, even if the information from the teachers' questionnaire is reported.

5.2 CATPCA technique

This section presents the results of the CATPCA, namely the eigenvalues and percentage of variance accounted for (PVAF) of all the countries used in this study, based on different teaching strategies used, the computer activities used and the specific mathematics content covered.

The data obtained from learners in all seven countries was linked to their teachers' responses and was categorical in nature. Therefore, it was imperative to use the CATPCA, as a data reduction technique to change these categorical responses into quantitative responses. The CATPCA output consists of the eigenvalues and the total PVAF related to each retained response. The eigenvalues and the PVAF were calculated using the data obtained from the number of learners who were taught by teachers who completed the TIMSS 2011 teachers' questionnaire.

a) Use of computer activities

This section reports on the analysis of the data obtained through Question 9 (A-C) and Question 22 (A-D) in the TIMSS 2011 teacher questionnaire. The eigenvalues and PVAF regarding the use of computer activities are presented in Table 5:1 based on the number of learners that were taught by teachers who provided their views.

Table 5:1 Use of computer activities - Eigenvalues and PVAF

Countries	Statistical measure	Factor 1	Factor 2	Total PVAF
a) Norway	Eigenvalues	2.220	1.815	57.64%
	PVAF	**31.71%**	25.93%	
b) Sweden	Eigenvalues	3.142	1.653	68.51%
	PVAF	44.89%	23.62%	
c) Saudi Arabia	Eigenvalues	3.918	1.401	75.99%
	PVAF	55.97%	**20.02%**	
d) South Africa	Eigenvalues	3.709	2.056	82.36%
	PVAF	52.99%	29.37%	
e) Thailand	Eigenvalues	4.041	2.138	88.27%
	PVAF	**57.72%**	**30.55%**	
f) Singapore	Eigenvalues	3.052	2.009	72.55%
	PVAF	43.61%	28.94%	
g) United Arab Emirates	Eigenvalues	3.059	1.633	67.04%
	PVAF	43.70%	23.34%	

A two-factor model approach was adopted for this question based on the factor loadings from South Africa. The PVAF of Factor 1 in this model ranges from 31.71% in Norway to 57.72% in Thailand. Furthermore, the second factor ranges between 20.02% (Saudi Arabia) and 30.55% (Thailand). Different colours in Table 5:1 indicate the variance accounted for with green depicting the highest and red the lowest point values, respectively. Furthermore, the grey area delineates the table into two groups, countries with higher (top) and lower (bottom) government expenditure on education than South Africa.

The total variance accounted for explained by these two factors was above 50%, which was acceptable for all the countries used in this study. These results demonstrate that the scale produces consistent results on each occasion.

b) Teaching strategies

This section reports on the analysis of the data obtained through Question 19 (A-J) in the TIMSS 2011 teacher questionnaire. The eigenvalues and PVAF related to the teaching strategies are presented in Table 5:2 based on the number of learners that were taught by teachers who provided their views. Note that different colours are used to illustrate the spread in the PVAF for each model, as was the case in Table 5:2.

Table 5:2 Teaching strategies - Eigenvalues and PVAF

Countries	Statistical measure	Factor 1	Factor 2	Factor 3	Total PVAF
a) Norway	Eigenvalues	2.541	1.745	1.456	52.20%
	PVAF	**23.10%**	15.86%	**13.24%**	
b) Sweden	Eigenvalues	3.267	1.250	1.144	51.47%
	PVAF	29.70%	**11.37%**	10.40%	
c) Saudi Arabia	Eigenvalues	2.541	1.745	1.456	52.20%
	PVAF	**23.10%**	15.86%	**13.24%**	
d) South Africa	Eigenvalues	3.016	1.479	1.099	50.85%
	PVAF	27.42%	13.44%	9.99%	
e) Thailand	Eigenvalues	3.711	2.428	1.083	65.65%
	PVAF	**33.73%**	**22.07%**	9.85%	
f) Singapore	Eigenvalues	3.709	1.701	1.052	58.74%
	PVAF	33.72%	15.46%	**9.56%**	
g) United Arab Emirates	Eigenvalues	2.914	1.523	1.085	50.18%
	PVAF	26.48%	13.84%	9.86%	

A three-factor model approach was adopted for this question based on the factor loadings from South Africa. The PVAF accounted for, regarding Factor 1 in this model, ranges from 23.10% (Norway) to 33.73% (Thailand). Furthermore, the PVAF regarding the second factor, ranges from 11.37% (Sweden) which was the lowest to the highest variance of 22.07% (Thailand). In conclusion, the PVAF pertaining to the third factor in this model ranges from 9.56% (Singapore) to 13.24% (Norway). The total variance accounted for by these three factors was above 50%, which was acceptable for all the countries used in this study. These results demonstrate that the scale produces consistent results on each occasion.

c) Specific mathematics content coverage

This section reports on the analysis of the information obtained by means of Question 30 (AA-DC) in the TIMSS 2011 teacher questionnaire. Table 5:3 indicates the eigenvalues and PVAF related to the specific mathematics content taught to the TIMSS classrooms by teachers who provided their responses. Again, note that different colour coding is used to illustrate the spread in the PVAF for each model.

Table 5:3 Content coverage - Eigenvalues and PVAF

Countries	Statistical measure	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Total PVAF
a) Norway	Eigenvalues	6.923	4.022	1.484	1.234	1.057	77.47%
	PVAF	36.44%	21.17%	7.81%	6.49%	5.56%	
b) Sweden	Eigenvalues	6.441	2.416	2.396	1.659	1.107	73.79%
	PVAF	33.90%	12.72%	**12.61%**	**8.73%**	5.83%	
c) Saudi Arabia	Eigenvalues	4.747	4.129	1.674	1.262	1.233	68.65%
	PVAF	**24.98%**	**21.73%**	8.81%	6.64%	**6.49%**	
d) South Africa	Eigenvalues	10.935	1.895	1.428	1.306	1.123	87.83%
	PVAF	**57.55%**	**9.98%**	**7.52%**	6.87%	5.91%	
e) Thailand	Eigenvalues	6.880	3.146	1.791	1.315	1.029	74.53%
	PVAF	36.21%	16.56%	9.43%	6.92%	**5.41%**	
f) Singapore	Eigenvalues	6.080	3.898	1.711	1.320	1.118	74.35%
	PVAF	32.00%	20.52%	9.00%	6.95%	5.88%	
g) United Arab Emirates	Eigenvalues	5.198	3.541	2.077	1.420	1.151	70.46%
	PVAF	27.36%	18.64%	10.93%	7.47%	6.06%	

A five-factor model approach was adopted for this question based on the factor loadings of South Africa. The PVAF of the first factors in this model ranges from 24.98% in Saudi Arabia to the highest variance of 57.55% (South Africa). The second factor ranges from 9.98% (South Africa) to the highest variance of 21.73% (Saudi Arabia), while the third factor ranges from 7.52% (South Africa) to the highest variance of 12.61% (Sweden). The fourth factor ranges from 6.64% (Saudi Arabia) to the highest variance of 8.73% (Sweden). Lastly, the fifth factor ranges from 5.41% (Thailand) to the highest variance of 6.49% (Saudi Arabia). The total variance explained by these five factors was above 50%, which was acceptable for all the countries used in this study. These results demonstrate that the scale produces consistent results on each occasion.

5.3 Orthogonal procrustean rotation

The Orthogonal procrustean rotation was used to position the teachers responses obtained from South Africa and their international counterparts in the same unit-metric space, irrespective of their early magnitude of their responses. It should be noted that the orthogonal procrustean rotation was used to rotate the teachers responses obtained from South Africa (comparison matrix), while all the other six countries (target matrices) compared with, were not rotated in this study.

5.4 Tucker congruent coefficient

The Tucker coefficient of congruence was the most appropriate index of similarity and it was used to compare the percentage of learners in South Africa with each of their international counterparts used in the study. The comparison was based on the number of learners whose teachers provided their views about the use of *computer activities, teaching strategies* as well as *teaching a specific mathematics content*.

The congruent coefficients were calculated after the South African learners responses were orthogonally rotated against their counterparts in the following countries, Norway, Sweden, Saudi Arabia, Thailand, United Arab Emirates and Singapore. If the congruent coefficients (Ø) were greater than, or equal to 0.95, the results indicated that the responses are similar in both countries. On the other hand, congruent coefficients below 0.95 indicated that teachers' responses between the two countries were not similar. Therefore, based on the analysis reliable comparisons could be made between South Africa and all six countries analysed in this study.

For example, if the Tucker Congruent coefficient for teachers in South Africa and Saudi Arabia is greater than 0.95 for their level of comfort in using computers in education, then it means that South Africans could possibly benefit from finding out why it is that teachers in Saudi Arabia feel so much more comfortable in using computers as part of their teaching and learning processes.

5.5 Research questions

The TIMSS 2011 teacher's background questionnaire gathered data about teachers' backgrounds, their training and how they think about mathematics. This chapter presents the results of the teachers' responses to some of these questions focusing on the three main research questions, namely:

Research question 1

How do South African learners compare with selected international counterparts with regards to how their teachers have used **computer activities?**

Research question 2

How do South African learners compare with selected international counterparts with regards to how their teachers have used different **teaching strategies?**

Research question 3

How do South African learners compare with selected international counterparts with regards to their teachers' preparedness to teach **specific mathematics content?**

5.6 Similarities regarding computer activities

This section provides the results of the analysis of data based on the research question, which asked how South African learners compare with their selected international counterparts based on their teachers' use of *computers in teaching and learning*. It should be noted that the conclusions are drawn based on the following statements:

a) If $Ø < 0.95$, then it can be construed that there were no **significant similarities** between South African learners and their selected international counterparts with regards to the use of computer activities.

b) If $Ø \geq 0.95$ then, it can be construed that there were **significant similarities** between South African learners and their selected international counterparts with regards to the use of computer activities.

Teachers were asked to indicate the rate of recurrence with regards to various computer activities used in their mathematics classrooms. Annexure J shows the component loadings and rotated component loadings between South Africa and each of the countries analysed in the study, based on the use of *computer activities*. The similarities between South Africa and each of the other countries will now be unpacked.

5.6.1 Similarities between Norway and South Africa

Table 5:4 presents the congruent coefficients between *South African* and *Norwegian* learners who were taught by teachers who responded to questions relating to the use of computers in the classroom.

Table 5:4 Congruent coefficients between South Africa and Norway

<table>
<tr><th colspan="5">Comparison between Norway and South Africa</th></tr>
<tr><th colspan="3">Teachers were asked to indicate whether “they agree with the following statements about the use of computers in their teaching”</th><th>Ø</th><th>Symbol</th></tr>
<tr><td colspan="3">a) Feel comfortable using computers in my teaching</td><td>0.64</td><td>○</td></tr>
<tr><td colspan="3">b) I have ready access to computer support staff in my school</td><td>0.99</td><td>●</td></tr>
<tr><td colspan="3">c) Adequate support for integrating computers in my teaching activities</td><td>0.96</td><td>●</td></tr>
<tr><th colspan="3">Teachers were asked, “how often do you have the students do the following computer activities during mathematics lesson?”</th><th>Ø</th><th>Symbol</th></tr>
<tr><td colspan="3">a) Explore mathematical principles and concepts</td><td>1.00</td><td>●</td></tr>
<tr><td colspan="3">b) Practice skills and procedures</td><td>0.98</td><td>●</td></tr>
<tr><td colspan="3">c) Look up ideas and information</td><td>1.00</td><td>●</td></tr>
<tr><td colspan="3">d) Process and analyse data</td><td>0.99</td><td>●</td></tr>
<tr><th colspan="3">Overall congruent coefficient</th><th>0.94</th><th>○</th></tr>
<tr><th colspan="5">RMSD</th></tr>
<tr><th>Countries</th><th>Norway</th><th>South Africa</th><th colspan="2">Index</th></tr>
<tr><td>Original</td><td>Actual input target</td><td>Original comparison matrix</td><td colspan="2">0.61</td></tr>
<tr><td>Comparison</td><td>Orthogonalised target</td><td>Maximally congruent comparison matrix</td><td colspan="2">0.35</td></tr>
</table>

The congruent coefficient compares unfavourably with the required threshold between the way Norwegian and South African teachers reported on their feelings with regards to the use of computers in their teaching (0.64). The congruent coefficient lower than the required threshold (0.95), indicated that no significant similarities were found between the two countries with regards *to feeling comfortable using computers in teaching*. It is, therefore, clear that the South African teachers’ responses were not the same as their Norwegian counterparts in terms of *how comfortable they feel about the use of computers in their teaching*.

In contrast, six computer activities generated congruent coefficients that are above 0.95 between teachers in South Africa and their Norwegian counterparts. The results showed that there were significant similarities in the way that teachers reported on the *adequate support they had for integrating computers into their* *teaching activities* (0.99) and *having ready access to computer staff in their school* (0.96).

The results also indicate that there are significant similarities about how teachers have asked their *learners do the following computer activities during mathematics lessons to explore mathematical principles and concepts* (1.00), *practise skills and procedures (0.98), look up ideas and information* (1.00) *and process and analyse data* (0.99). Therefore, it can be concluded that significant similarities were found between the two countries with regards to the items where the congruent coefficients were above the required threshold of 0.95. In contrast, the overall congruent coefficient of 0.94 is lower than the required threshold. Therefore, no significant similarities were found overall between learners in both countries with regards to the use of computers in teaching and learning.

It may be valuable to further investigate how the Norwegian teachers use computer activities in their mathematics classrooms looking at those items that showed a congruent coefficient of more than 0.95. This is prompted by the fact that Norwegian learners (475 out of 1 000) outperformed their South African (352 out of 1 000) counterparts during the TIMSS 2011 investigation.

5.6.2 Similarities between Sweden and South Africa

Table 5:5 presents the congruent coefficients between *Sweden* and *South African* learners who were taught by teachers who responded to questions relating to the use of computers in the classroom.

Table 5:5 Congruent coefficients between South Africa and Sweden

Comparison between Sweden and South Africa		
Teachers were asked to indicate whether "they agree with the following statements about the use of computers in their teaching"	**Ø**	**Symbol**
a) Feel comfortable using computers in my teaching	0.75	○
b) I have ready access to computer support staff in my school	0.99	●
c) Adequate support for integrating computers in my teaching activities	0.99	●
Teachers were asked, "how often do you have the students do the following computer activities during mathematics lesson?"	**Ø**	**Symbol**
a) Explore mathematical principles and concepts	0.99	●
b) Practice skills and procedures	1.00	●

Comparison between Sweden and South Africa			
c) Look up ideas and information		1.00	●
d) Process and analyse data		0.99	●
Overall congruent coefficient		**0.96**	●
RMSD			
Countries	**Sweden**	**South Africa**	**Index**
Original	Actual input target	Original comparison matrix	0.36
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.29

The results show no similarities between the manner in which the Swedish and South African teachers reported on *how comfortable they felt with regards to the use of computers in their teaching* (0.75). The congruent coefficient compares unfavourably with the required threshold. Therefore, the results suggest that no significant similarities were found with regards to this item. It is, therefore, clear that teachers in South Africa and their Swedish counterparts were different in terms of *how comfortable they feel about the use of computers in teaching* and that no further comparisons can be made with regards to this item.

However, the analysis of the data generated congruent coefficients that were above 0.95 in quite a number of the items, and as such, it is fair to deduce that South Africa can benefit from exploring the way in which Sweden addresses these issues. For example, because of the congruent coefficient of 0.99 we know that it is possible to compare the *ready access* that Swedish teachers have *to computer staff in their schools* to the access that the South African teachers have.

There are further items where the congruent coefficient between Sweden and South Africa makes it possible for us to explore the similarities in that item, for example the way that teachers reported on the *adequate support they had for integrating computers into their teaching activities* (0.99). Furthermore, the following items yielded congruent coefficients that were above the required threshold based on the teachers' perspectives about *how often their learners have used computer activities during mathematics lessons to*

- *explore mathematical principles and concepts* (0.99),
- *practise skills and procedures* (1.00),
- *look up ideas and information* (1.00) and

- *process and analyse data* (0.99).

Therefore, it can be concluded that significant similarities were found between the two countries with regards to the items where the congruent coefficients were above the required threshold of 0.95.

In addition, the overall congruent coefficient regarding teachers' self-reporting on the *use of computers* in the classroom was 0.96, which is above the required threshold. Therefore, it can be concluded that significant similarities were found overall between the two countries with regards to the overall congruent coefficient. Furthermore, the RMSD was lower after rotation (0.29) than before (0.36). The low value of the RMSD after rotation indicates that the teachers self-reports about the use of computers between the two countries were close to one another.

It should be taken into consideration that the Swedish learners (484 out of 1 000) outperformed their South African (352 out of 1 000) counterparts, and that it may therefore be of value to investigate how the Swedish teachers use computer activities in their mathematics classrooms with regards to those items that showed significant similarities.

5.6.3 Similarities between Saudi Arabia and South Africa

Table 5:6 presents the congruent coefficients between *Saudi Arabian* and *South African* learners who were taught by teachers who responded to questions relating to the use of computers in the classroom. The congruent coefficient is a measure of significance in terms of the differences or similarities between the two countries.

Table 5:6 Congruent coefficients between Saudi Arabia and South Africa

Comparison between Saudi Arabia and South Africa		
Teachers were asked to indicate whether "they agree with the following statements about the use of computers in their teaching"	**Ø**	**Symbol**
a) Feel comfortable using computers in my teaching	0.99	●
b) I have ready access to computer support staff in my school	0.98	●
c) Adequate support for integrating computers in my teaching activities	0.90	○
Teachers were asked, "how often do you have the students do the following computer activities during mathematics lesson?"	**Ø**	**Symbol**
a) Explore mathematical principles and concepts	0.96	●

b) Practice skills and procedures			0.89	○
c) Look up ideas and information			0.98	●
d) Process and analyse data			0.99	●
Overall congruent coefficient			**0.96**	●
RMSD				
Countries	**Saudi Arabia**	**South Africa**	**Index**	
Original	Actual input target	Original comparison matrix	0.36	
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.29	
Green circle shows values equal to or greater than 0.95; Red circle shows values less than 0.95.				

The analysis of the data shows that no similarities were established between the way Saudi Arabian and South African teachers reported on the *adequate support they had for integrating computers into their teaching activities* (0.90). Furthermore, the results did not show any significant similarities between the manner in which teachers in Saudi Arabia allowed their learners to *practice skills and procedures* (0.89), and the way this is done by their counterparts in South Africa. The congruent coefficients lower than the required threshold (0.95), suggest that no significant similarities were found between the two countries with regards to these two items. It is, therefore, clear that South African teachers cannot compare themselves to their Saudi Arabian counterparts in terms of the *adequate support they had for integrating computers into their teaching activities.* The same can be said about how often teachers in both countries have allowed their learners to use computer activities to *practise skills and procedures*.

However, significant similarities were found between these two countries with regards to how *comfortable teachers felt about using computers in their teaching* (0.99) and having *ready access to computer staff in their schools* (0.98). Furthermore, favourable results were also found in the way teachers in Saudi Arabia and South Africa reported on *how often their students used computer activities during mathematics lessons* to *explore mathematical principles and concepts* (0.96), *look up ideas and information* (0.98), and *process and analyse data* (0.99). The congruent coefficient calculated for each item (higher than the required threshold) suggests that significant similarities were found between learners in South Africa and Saudi Arabia with regards to how *often their students* *used computer activities during mathematics lessons*. Therefore, it can be deduced that teachers in both countries have reported in a similar manner.

In addition, the overall congruent coefficient, regarding teachers' self-reporting on the use of computers in the classroom, was 0.96, which is above the required threshold. The root-mean-square deviation (RMSD) ranged from 0.29 before to 0.36 after the rotation. The low value of the RMSD after rotation indicates that the teachers' views about the use of computers between the two countries were close to each other. The overall congruent coefficient suggests that significant similarities were found overall between learners in South Africa and Saudi Arabia with regards to how their teachers have used computer in the classroom. Therefore, it can be deduced that teachers in both countries have reported in a similar manner.

Seeing that learners in Saudi Arabia (415 out of 1 000) outperformed South African learners (352 out of 1 000) during the TIMSS 2011 study, it is imperative to further explore the way in which teachers in Saudi Arabia use computers in teaching and learning, as there may be a relationship between this variable and the learners' performance in mathematics.

5.6.4 Similarities between Thailand and South Africa

Table 5:7 presents the congruent coefficients between *South African* and *Thai* learners who were taught by teachers who responded to questions relating to their use of computers in the classroom.

Table 5:7 Congruent coefficients between Thailand and South Africa

Comparison between Thailand and South Africa		
Teachers were asked to indicate whether they agree with the following statements about the use of computers in their teaching	**Ø**	**Symbol**
a) Feel comfortable using computers in my teaching	0.75	○
b) I have ready access to computer support staff in my school	0.99	●
c) Adequate support for integrating computers in my teaching activities	0.97	●
Teachers were asked, "How often do you have the students do the following computer activities during mathematics lesson?"	**Ø**	**Symbol**
a) Explore mathematical principles and concepts	1.00	●
b) Practice skills and procedures	1.00	●

Comparison between Thailand and South Africa				
c) Look up ideas and information			1.00	●
d) Process and analyse data			1.00	●
Overall congruent coefficient			**0.96**	●
RMSD				
Countries	**Thailand**	**South Africa**	**Index**	
Original	Actual input target	Original comparison matrix	0.31	
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.29	

It is evident from the results that no similarities were found between the way Thai and South African teachers reported on their feelings pertaining to *feeling comfortable using computers in their teaching* (0.75). The congruent coefficient is less than the required threshold. It is, therefore, clear that teachers in South Africa cannot compare themselves to their Thai counterparts in terms of how comfortable they feel about the use of computers in their teaching.

However, the analysis of the data generated congruent coefficients that were above 0.95 for the two countries in quite a number of the items, and as such, it is fair to deduce that South Africa can benefit from exploring the way in which Thailand addresses these issues. For example, because of the congruent coefficient value of 0.99, we know that it is possible to compare the *ready access* that Thailand teachers have *to computer staff in their schools* to those in South Africa. There are further items where the congruent coefficient value between Thailand and South Africa make it possible for us to explore the differences in that item, for example the way that teachers reported on the *adequate support they had for integrating computers into their teaching activities* (0.97).

Other similarities between these two countries, South Africa and Thailand, include *how often do teachers have their students do the following computer activities during mathematics lessons to*

- *explore mathematical principles and concepts* (1.00),
- *practise skills and procedures* (1.00),
- *look up ideas and information* (1.00) and
- *process and analyse data* (1.00).

The congruent coefficients are higher than the required threshold of 0.95. Therefore, it can be concluded that significant similarities were found between learners in both countries with regards *to how teachers have asked their learners to do various computer activities during mathematics lessons*.

The overall congruent coefficient regarding teachers' self-reporting on their use of computers in the classroom was 0.96, which is above the required threshold. Therefore, the overall congruent coefficient suggests that significant similarities were found overall between learners in both countries with regards to the use of computers in teaching and learning. For example 87.5% of the items showed acceptable congruent coefficients for both the South African teachers and their Thai counterparts. In conclusion, the low value of the RMSD shows that the teachers' views between the two countries were close to each other.

Since Thai learners (427 out of 1 000) outperformed their South African (352 out of 1 000) counterparts with points, it may be of value to investigate how teachers in Thailand use computer activities in their mathematics classrooms with regards to those items that showed a congruent coefficient of more than 0.95.

5.6.5 Similarities between Singapore and South Africa

Table 5:8 presents the congruent coefficients between *Singaporean* and *South African* learners who were taught by teachers who responded to questions relating to their use of computers in the classroom.

Table 5:8 Congruent coefficients between Singapore and South Africa

Comparison between Singapore and South Africa			
Teachers were asked to indicate whether they agree with the following statements about the use of computers in their teaching		**Ø**	**Symbol**
a)	Feel comfortable using computers in my teaching	0.86	○
b)	I have ready access to computer support staff in my school	1.00	●
c)	Adequate support for integrating computers in my teaching activities	0.98	●
Teachers were asked, "How often do you have the students do the following computer activities during mathematics lesson?"		**Ø**	**Symbol**
a)	Explore mathematical principles and concepts	1.00	●
b)	Practice skills and procedures	1.00	●
c)	Look up ideas and information	0.99	●

Comparison between Singapore and South Africa				
d) Process and analyse data			1.00	●
Overall congruent coefficient			**0.97**	●
RMSD				
Countries	**Singapore**	**South Africa**	Index	
Original	Actual input target	Original comparison matrix	0.40	
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.22	

The analysis of the data shows that there are no similarities between the way teachers in Singapore and South Africa reported on their feelings with regards *to feeling comfortable using of computers in their teaching* (0.86). There is sufficient evidence from the analysis which suggests that no significant similarities were found between the two countries with regards to this item. It is, therefore, clear that teachers in South Africa cannot compare themselves to their Singaporean counterparts in terms of how comfortable they feel about the use of computers in their teaching.

However, the analysis of the data generated congruent coefficients that were above 0.95 in 87.5% of the items. There is empirical evidence to deduce that South Africa can benefit from exploring the way in which Singapore addresses these issues. It is clear from the results that it is possible to compare the teachers' ready access computer staff in their schools (1.00) and the support they had for integrating computers into their teaching activities (0.98) between South Africa and their Singaporean counterparts.

There are further items where the congruent coefficient between Singapore and South Africa makes it possible to explore the similarities, such as *how teachers have allowed their learners do the following computer activities during mathematics lessons* to

- *explore mathematical principles and concepts* (1.00),
- *practise skills and procedures* (1.00),
- *look up ideas and information* (0.99) and
- *process and analyse data* (1.00).

Therefore, it can be concluded that significant similarities were found between learners in both countries with regards to how teachers have asked their learners to use computer activities during mathematics lessons. Furthermore, the overall congruent coefficient regarding teachers' self-reporting on their use of computers in the classroom was 0.97, which is above the required threshold. Since these congruent coefficients compare favourably with the recommendation of 0.95 they can therefore be regarded as acceptable for equivalence for teachers in the two countries, South Africa and Singapore. Therefore, the overall congruent coefficient suggests that significant similarities were found between learners in both countries with regards to how their teachers have used different teaching strategies. Furthermore, a lower value of the RMSD, after rotation, also indicates that teachers' views between the two countries were closer to each other than before rotation.

Since Singaporean learners (611 out of 1 000) outperformed their South African (352 out of 1 000) counterparts, it may be of value to investigate how the Singaporean teachers use computer activities in their mathematics classrooms with regards to those items that showed a congruent coefficient of more than 0.95.

5.6.6 Similarities between the United Arab Emirates and South Africa

Table 5:9 presents the congruent coefficients between the *United Arab Emirates* and *South African* learners who were taught by teachers who responded to questions relating to their use of computers in the classroom.

In this study, it is imperative to investigate how the United Arab Emirates teachers use computer activities in their mathematics classrooms. Since United Arab Emirates learners (456 out of 1 000) outperformed their South African (352 out of 1 000) counterparts.

Table 5:9 Congruent coefficients between the United Arab Emirates and South Africa

Comparison between United Arab Emirates and South Africa		
Teachers were asked to indicate whether they agree with the following statements about the use of computers in their teaching	**Ø**	**Symbol**
a) Feel comfortable using computers in my teaching	0.59	○
b) I have ready access to computer support staff in my school	0.99	●

Comparison between United Arab Emirates and South Africa				
c) Adequate support for integrating computers in my teaching activities			0.99	●
Teachers were asked, "How often do you have the students do the following computer activities during mathematics lesson?"			**Ø**	**Symbol**
a) Explore mathematical principles and concepts			0.98	●
b) Practice skills and procedures			0.99	●
c) Look up ideas and information			1.00	●
d) Process and analyse data			0.99	●
Overall congruent coefficient			**0.93**	○
RMSD				
Countries	**United Arab Emirates**	**South Africa**	**Index**	
Original	Actual input target	Original comparison matrix	0.42	
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.37	

The analysis of the data shows that there is little similarity between the way United Arab Emirates and South African teachers reported on their feelings with regards *to feeling comfortable in using computers in their teaching* (0.59). The congruent coefficient is lower than the required threshold. It is, therefore, clear that South Africa cannot compare itself to the United Arab Emirates in terms of how comfortable they feel about the use of computers in their teaching.

However, the analysis of the data generated congruent coefficients that were above 0.95 for the two countries in 87.5% of the items, and as such it is fair to deduce that South Africa can benefit from exploring the way in which the United Arab Emirates addresses these issues. It is clear from the results that it is possible to compare the *ready access computer staff in their schools* (0.99) and the *adequate support they had for integrating computers* into their teaching activities (0.99) between South Africa and their United Arab Emirates counterparts.

There are further items where the congruent coefficients between the United Arab Emirates and South Africa where above 0.95 which included *how often teachers have asked their learners do the following computer activities during mathematics lessons to*

- *explore mathematical principles and concepts* (0.98),
- *practise skills and procedures* (0.99),
- *look up ideas and information* (1.00) and

- *process and analyse data* (0.99).

Therefore, it can be concluded that significant similarities were found between learners in both countries with regards to *how often teachers have asked their learners use different computer activities during mathematics lessons*.

In contrast, the overall congruent coefficient regarding teachers' self-reporting on their use of computers in the classroom was 0.93, which is below the required threshold. The RMSD ranged from 0.42 before to 0.37 after rotation**.** The lower value of the RMSD also indicates that the teachers; views between the two countries were brought close to each other. Therefore, the overall results indicate that no significant similarities were found overall between learners in both countries with regards to how their teachers have asked them to used different computer activities in teaching and learning.

5.6.7 Summary of similarity results about computer activities

Table 5:10 shows the summary of the similarity results between South Africa and each of the countries analysed in this study.

Table 5:10 Summary the use of computer activities

	Countries with					
Variables selected from the TIMSS 2011 Teacher Questionnaire	**Higher government expenditure on education**			**Lower government expenditure on education**		
Teachers' self-reporting on their use of computers in the classroom	**NOR**	**SWE**	**SAU**	**THA**	**SGP**	**UAE**
a) Feel comfortable using computers in my teaching	0.64	0.75	**0.99**	0.75	0.86	0.59
b) I have ready access to computer support staff in my school	**0.99**	0.99	**0.98**	0.99	1.00	0.99
c) Adequate support for integrating computers in my teaching activities	**0.96**	0.99	0.90	0.97	0.98	0.99
Specific computer activities used in the classroom						
a) Explore mathematical principles and concepts	**1.00**	0.99	**0.96**	1.00	1.00	0.98
b) Practise skills and procedures	**0.98**	1.00	**0.98**	1.00	1.00	0.99
c) Look up ideas and information	**1.00**	1.00	**0.99**	1.00	0.99	1.00
d) Process and analyse data	**0.99**	0.99	**0.99**	1.00	1.00	0.99
Overall congruent coefficient	0.94	0.96	0.96	0.96	0.97	0.93
The red colour indicates the congruent coefficients below 0.95						

The overall congruent coefficients were above the required threshold for four (out of six) countries analysed in this study, namely Saudi Arabia, Sweden, Thailand and Singapore. Therefore, it can be deduced that the government expenditure on education is not the only factor that influences the use of computer activities in their mathematics classrooms. It is evident from the results that the South African government could benefit from fostering relationships with their (Saudi Arabian, Swedish, Thai and Singaporean) counterparts on the use of computer activities in mathematics classrooms with regards to those items that showed a congruent coefficient of more than 0.95.

5.7 Similarities regarding teaching strategies

This section provides the results based on the teachers' views on the research question 2, namely "How do South African learners compare with their selected international counterparts with regards to how their teachers have used different ***teaching strategies***?" That said, Annexure K indicates the component loadings and the rotated component loadings between South Africa and each of the countries analysed in the study based on their teaching strategies.

It should be noted that the conclusions are drawn based on the following statements:

a) If $Ø < 0.95$, then the results show that there were **no significant similarities** between South African learners and their selected international counterparts with regards to **teaching strategies**.

b) If $Ø \geq 0.95$ then, the results show that there were **significant similarities** between South African learners and their selected international counterparts with regards to **teaching strategies**.

5.7.1 Similarities between Norway and South Africa

Table 5:11 presents the congruent coefficients between *South Africa*n and *Norwegian* learners who were taught by teachers who responded to questions relating to their use of different teaching strategies.

Table 5:11 Congruent coefficients between Norway and South Africa

Teachers were asked "How often do you usually ask students to do the following"			Ø	Symbol
a) Listen to the teacher explaining how to solve			0.92	○
b) Memorize rules, procedures and facts			0.80	○
c) Work problems (individually or with peers) with the teacher's guidance			0.74	○
d) Work problems together in the class with direct guidance form the teacher			0.83	○
e) Work while occupied			0.78	○
f) Apply facts, concepts and procedures to solve routine problems			0.70	○
g) Explain their answers			0.67	○
h) Relate what they are learning in mathematics to their daily life			0.98	●
i) Decide on their own procedures for solving complex problems			0.54	○
j) Work on problems for which there is no immediately obvious method of solution			0.96	●
k) Take a written test or quiz			0.58	○
Overall congruent coefficient			**0.77**	○
RMSD				
Countries	**Norway**	**South Africa**	**Index**	
Original	Actual input target	Original comparison matrix	0.80	
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.68	

The congruent coefficient results show that there are equal similarities on how teachers have asked learners to *relate what they are learning in mathematics to their daily life* (0.98) and *work on problems for which there is no immediate obvious method of solution* (0.96). It is clear from the results that 18% of the teaching strategies generated congruent coefficient values that were above 0.95. The congruent coefficient computed suggests that there were significant similarities between how South African teachers compared with their Norwegian counterparts with regards to their teaching strategies. It can be deduced that teachers in both countries have implemented these teaching strategies in a similar manner.

A different pattern was found with the remaining nine teaching strategies (82%) where the congruent coefficients were less than 0.95. Similarly, the overall congruent coefficient regarding the teaching strategies (0.77) was less than the required threshold. The overall congruent coefficient calculated suggested that no overall significant similarities were found between how South African teachers compare with their Norwegian counterparts with regards to their teaching strategies.

5.7.2 Similarities between Sweden and South Africa

Table 5:12 shows the congruent coefficients between *Sweden* and *South African* learners who were taught by teachers who responded to questions relating to their use of different teaching strategies.

Table 5:12 Congruent Coefficients between Sweden and South Africa

Teachers were asked "How often do you usually ask students to do the following"			Ø	Symbol
a) Listen to the teacher explaining how to solve			0.97	●
b) Memorize rules, procedures and facts			0.97	●
c) Work problems (individually or with peers) with the teacher's guidance			0.65	○
d) Work problems together in the class with direct guidance form the teacher			0.82	○
e) Work while occupied			0.97	●
f) Apply facts, concepts and procedures to solve routine problems			0.95	●
g) Explain their answers			0.97	●
h) Relate what they are learning in mathematics to their daily life			0.93	○
i) Decide on their own procedures for solving complex problems			0.81	○
j) Work on problems for which there is no immediately obvious method of solution			0.88	○
k) Take a written test or quiz			0.19	○
Overall congruent coefficient			**0.83**	○
RMSD				
Countries	**Sweden**	**South Africa**	**Index**	
Original	Actual input target	Original comparison matrix	0.73	
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.59	

The congruent coefficient results indicate that there are significant similarities between Sweden and South Africa on how teachers have asked learners to *listen to the teacher explaining how to solve* (0.97), *memorise rules, procedures and facts* (0.97), *work while occupied* (0.97), *apply facts, concepts and procedures to solve routine problems* (0.95) and *explain their answers* (0.97). It is clear from the results that five out of eleven teaching strategies generated congruent coefficients that are above 0.95 between the two countries. The congruent coefficient calculated for each item (higher than 0.95) suggests that significant similarities were found between learners in South Africa and their counterparts in Sweden with regards to their teaching strategies. It can be deduced that teachers in both countries have implemented these teaching strategies in a similar manner.

In contrast, with reference the remaining eight teaching strategies (55%) the congruent coefficients are less than the threshold. Furthermore, the overall congruent coefficient of 0.83 regarding the teaching strategies was less than the required threshold. Therefore, the overall congruent coefficient suggests that no significant similarity was found overall between how South African teachers compare with their Swedish counterparts with regards to their teaching strategies.

5.7.3 Similarities between Saudi Arabia and South Africa

Table 5:13 presents the congruent coefficients between Saudi Arabian and South African learners who were taught by teachers who responded to questions relating to their use of different teaching strategies.

Table 5:13 Congruent coefficients between Saudi Arabia and South Africa

Teachers were asked "How often do you usually ask students to do the following"	**Ø**	**Symbol**
a) Listen to the teacher explaining how to solve	0.69	○
b) Memorize rules, procedures and facts	-0.02	○
c) Work problems (individually or with peers) with the teacher's guidance	0.77	○
d) Work problems together in the class with direct guidance form the teacher	0.51	○
e) Work while occupied	1.00	●
f) Apply facts, concepts and procedures to solve routine problems	0.85	○
g) Explain their answers	0.96	●
h) Relate what they are learning in mathematics to their daily life	0.87	○
i) Decide on their own procedures for solving complex problems	1.00	●
j) Work on problems for which there is no immediately obvious method of solution	0.92	○
k) Take a written test or quiz	0.50	○
Overall congruent coefficient	**0.73**	○

RMSD			
Countries	**Saudi Arabia**	**South Africa**	**Index**
Original	Actual input target	Original comparison matrix	0.75
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.73

The results indicate that there are similarities between Saudi Arabia and South Africa on how teachers have asked learners to *work while occupied* (1.00), *to* *explain their answers* (0.97) and *to decide on their own procedures for solving complex problems* (1.00). It is clear from the results that three out of eleven teaching strategies (27%) generated congruent coefficients that are above 0.95 between the two countries. It can be deduced that teachers in both countries have implemented these teaching strategies in the same manner. Therefore, the results from the analysis indicate that significant similarities were found between how South African teachers compared with their Saudi Arabian counterparts with regards to these three teaching strategies.

On the other hand, with reference to the remaining eight teaching strategies (73%) the congruent coefficients were less than 0.95. Similarly, the overall congruent coefficient of 0.73, regarding all the eleven teaching strategies, was less than the required threshold. The congruent coefficient calculated for each item (lower than 0.95) suggests that no similarity was found overall between South Africa and Saudi Arabia with regards to how their teachers have used different teaching strategies. In particular, the congruent coefficient results indicated that the number of learners who were taught by these teachers in the two countries, are not similar enough to reach conclusions.

5.7.4 Similarities between Thailand and South Africa

Table 5:14 presents the congruent coefficients between *Thai* and *South African* learners who were taught by teachers who responded to questions relating to their use of different teaching strategies.

Table 5:14 Congruent coefficients between Thailand and South Africa

Teachers were asked "How often do you usually ask students to do the following?"	Ø	Symbol
a) Listen to the teacher explaining how to solve	0.68	○
b) Memorize rules, procedures and facts	0.90	○
c) Work problems (individually or with peers) with the teacher's guidance	0.58	○
d) Work problems together in the class with direct guidance form the teacher	0.84	○
e) Work while occupied	0.97	●
f) Apply facts, concepts and procedures to solve routine problems	0.99	●
g) Explain their answers	0.54	○
h) Relate what they are learning in mathematics to their daily life	0.85	○
i) Decide on their own procedures for solving complex problems	0.92	○

Teachers were asked "How often do you usually ask students to do the following?"				Ø	Symbol
j) Work on problems for which there is no immediately obvious method of solution				0.92	○
k) Take a written test or quiz				0.90	○
Overall congruent coefficient				**0.83**	○
RMSD					
Countries	**Thailand**	**South Africa**	**Index**		
Original	Actual input target	Original comparison matrix	0.74		
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.58		

The results indicate that there are similarities on how South African teachers and their Thai counterparts have asked learners to *work while occupied* (0.97) and *apply facts, concepts and procedures to solve routine problems* (0.99). The congruent coefficients higher than the required threshold suggested that there were significant similarities between how South African teachers compared with their Thai counterparts with regards to their teaching strategies. It can be deduced that teachers in both countries have implemented these teaching strategies in the same manner.

In contrast, with reference to the remaining nine teaching strategies (82%), the congruent coefficients are less than 0.95. Similarly, the overall congruent coefficient regarding the teaching strategies (0.83) was less than the required threshold. There are no overall similarities between how South African teachers compare with their Thai counterparts with regards to their teaching strategies.

5.7.5 Similarities between Singapore and South Africa

Table 5:15 presents the congruent coefficients between *South Africa* and *Singapore* learners who were taught by teachers who responded to questions relating to their use of different teaching strategies.

Table 5:15 Congruent coefficients between Singapore and South Africa

Teachers were asked "How often do you usually ask students to do the following?"	Ø	Symbol
a) Listen to the teacher explaining how to solve	1.00	●
b) Memorize rules, procedures and facts	0.99	●
c) Work problems (individually or with peers) with the teacher's guidance	0.57	○
d) Work problems together in the class with direct guidance form the teacher	0.97	●

Teachers were asked "How often do you usually ask students to do the following?"			Ø	Symbol
e) Work while occupied			0.54	○
f) Apply facts, concepts and procedures to solve routine problems			0.79	○
g) Explain their answers			0.83	○
h) Relate what they are learning in mathematics to their daily life			0.95	•
i) Decide on their own procedures for solving complex problems			0.98	•
j) Work on problems for which there is no immediately obvious method of solution			0.98	•
k) Take a written test or quiz			0.56	○
Overall congruent coefficient			**0.83**	○
RMSD				
Countries	**Singapore**	**South Africa**	**Index**	
Original	Actual input target	Original comparison matrix	0.42	
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.57	

It is clear from the results that 55% of the teaching strategies generated congruent coefficients that were above 0.95 between the two countries. The results indicate that there are equal similarities on how teachers have asked learners to *listen to the teacher explaining how to solve* (1.00), *memorise rules, procedures and facts* (0.99), *work problems together in the class with direct guidance from the teacher* (0.97), *relate what they are learning in mathematics to their daily life* (0.95), *decide on their own procedures for solving complex problems* (0.98) and *work on problems for which there is no immediate obvious method of solution* (0.98). The congruent coefficients calculated for each item suggested that there were significant similarities between how South African teachers compared with their Singaporean counterparts with regards to their teaching strategies. It can be deduced that teachers in both countries have implemented these teaching strategies in the same manner.

On the other hand, with reference the remaining nine teaching strategies (45%) the congruent coefficients are less than 0.95. The congruent coefficients computed for these items suggest that no significant similarities exist between how South African teachers compare with their Singaporean counterparts with regards to their teaching strategies. Furthermore, the overall congruent coefficient regarding all eleven the teachings strategies (0.83) is less than the required threshold.

5.7.6 Similarities between United Arab Emirates and South Africa

Table 5:16 presents the congruent coefficients between *South Africa* and *United Arab Emirates* learners who were taught by teachers who responded to questions relating to their use of different teaching strategies.

Table 5:16 Congruent coefficients between United Arab Emirates and South Africa

Teachers were asked "How often do you usually ask students to do the following?"	Ø	Symbol
a) Listen to the teacher explaining how to solve	0.97	●
b) Memorize rules, procedures and facts	0.67	○
c) Work problems (individually or with peers) with the teacher's guidance	0.96	●
d) Work problems together in the class with direct guidance form the teacher	0.79	○
e) Work while occupied	0.82	○
f) Apply facts, concepts and procedures to solve routine problems	0.92	○
g) Explain their answers	0.98	●
h) Relate what they are learning in mathematics to their daily life	0.66	○
i) Decide on their own procedures for solving complex problems	1.00	●
j) Work on problems for which there is no immediately obvious method of solution	0.98	●
k) Take a written test or quiz	0.95	●
Overall congruent coefficient	**0.88**	○

RMSD			
Countries	**United Arab Emirates**	**South Africa**	**Index**
Original	Actual input target	Original comparison matrix	0.77
Comparison	Orthogonalised target	Maximally congruent comparison matrix	0.49

It is clear from the results that six out of eleven teaching strategies (55%) generated congruent coefficients that were above 0.95 between the two countries. The results indicate that there are equal similarities on how teachers have asked learners *to listen to the teacher explaining how to solve* (1.00), *work problems (individually or with peers) with the teacher's guidance* (0.96), *explain their answers* (0.98), *decide on their own procedures for solving complex problems* (1.00), *work on problems for which there is no immediately obvious method* (0.98) and *take a written test or quiz* (0.95). The congruent coefficients calculated indicate that there were significant similarities between how South African learners compared with their United Arab Emirates counterparts with regards to their teaching strategies. It can be deduced that teachers in both countries have implemented these teaching strategies in the same manner.

On the other hand, with reference to the remaining five teaching strategies (45%) the congruent coefficients are less than 0.95. Furthermore, the overall congruent coefficients regarding all eleven the teaching strategies (0.88) is less than the required threshold. The congruent coefficients lower than the required threshold implies that no significant similarities were found between how South African learners compared with their United Arab Emirates counterparts with regards to their teaching strategies.

5.7.7 Summary of the similarity results about teaching strategies

Table 5:17 shows the summary of the congruent coefficients indicating the degree of similarity between South Africa and each of the countries.

Table 5:17 Summary of the similarities

Teachers were asked "How often do you usually ask students to do the following?"	NOR	SWE	SAU	THA	SGP	UAE
a) Listen to the teacher explaining how to solve	0.69	0.97	0.69	0.68	1.00	0.97
b) Memorize rules, procedures and facts	- 0.02	0.97	- 0.02	0.90	0.99	0.67
c) Work problems (individually or with peers) with the teacher's guidance	0.77	0.65	0.77	0.58	0.57	0.96
d) Work problems together in the class with direct guidance form the teacher	0.51	0.82	0.51	0.84	0.97	0.79
e) Work while occupied	1.00	0.97	1.00	0.97	0.54	0.82
f) Apply facts, concepts and procedures to solve routine problems	0.85	0.95	0.85	0.99	0.79	0.92
g) Explain their answers	0.96	0.97	0.96	0.54	0.83	0.98
h) Relate what they are learning in mathematics to their daily life	0.87	0.93	0.87	0.85	0.95	0.66
i) Decide on their own procedures for solving complex problems	1.00	0.81	1.00	0.92	0.98	1.00
j) Work on problems for which there is no immediately obvious method of solution	0.92	0.88	0.92	0.92	0.98	0.98
k) Take a written test or quiz	0.50	0.19	0.50	0.90	0.56	0.95
Overall congruent coefficient	**0.73**	**0.83**	**0.73**	**0.83**	**0.83**	**0.88**

Significant similarities were found between teachers in South Africa and some of their international counterparts with regards to how they have used different teaching strategies. However, the overall consolidated results reveal that there are no significant similarities between South Africa and any of the six countries analysed in the study based on their teaching strategies. The similarities ranged from 0.73 (Saudi Arabia) to 0.88 (United Arab Emirates).

It can be deduced that teachers in South Africa and their international counterparts have not used these teaching strategies in the same manner. Therefore, intervention strategies should be established between teachers in South Africa and their international counterparts about how they have used different teaching strategies. Furthermore, communities of practice could be established so that teachers could be provided with opportunities to learn from each other. South African teachers could learn from the international counterparts about how they have used different teaching strategies in their mathematics classrooms. It has been argued that it is hard to find solid evidence which shows that the introduction of computers into teaching and learning produces significant improvements in academic performance (Säljö, 2010). This author further argued that computers do not necessarily improve educational practices, and if they do, this will not be in a uniform manner. It seems as if the current study supports this notion.

5.8 Similarities regarding content coverage

This section provides the results based on research question 3, which stated that "How do South African learners compare with their selected international counterparts with regards to how well prepared their teachers felt about teaching **specific mathematics topics**?" It should be noted that teachers were asked to indicate if a particular topic was not taught in Grade 8, or whether they were not responsible for teaching the topic.

Annexure L shows the content coverage component loadings and rotated component loadings between South Africa and each of the countries analysed in the study. It should be noted that, once again the conclusions are drawn based on the following statements.

a) If $Ø < 0.95$, then there were **no significant similarities** between South African learners and their selected international counterparts with regards to their teachers' **preparedness to teach specific mathematics topics**.
b) If $Ø \geq 0.95$ then, there were **significant similarities** between South African learners and their selected international counterparts with regards to their teachers **preparedness to teach specific mathematics topics**.

5.8.1 Similarities between Norway and South Africa

Table 5:18 presents the congruent coefficients between *Norwegian* and *South African* learners who were taught by teachers who responded to questions relating to their preparedness to teach specific mathematics content.

Table 5:18 Congruent coefficients between Norway and South Africa

Mathematics topics		
Numbers (5 sub-topics)	**Ø**	**Symbol**
a) Computing, estimating, or approximating with whole numbers	0.62	○
b) Concepts of fractions and computing with fractions	0.54	○
c) Concepts of decimals and computing with decimals	0.39	○
d) Representing, comparing, ordering, and computing with integers	0.57	○
e) Problem solving involving percentages and proportions	0.69	○
Algebra (5 sub-topics)	**Ø**	**Symbol**
a) Numeric, algebraic, and geometric patterns or sequences	0.71	○
b) Simplifying and evaluating algebraic expressions	0.80	○
c) Simple linear equations and inequalities	0.67	○
d) Simultaneous (two variables equations	0.90	○
e) Representation of functions as ordered pairs, tables, graphs, words, or equations	0.85	○
Geometry (6 sub-topics)	**Ø**	**Symbol**
a) Geometric properties of angles and geometric shapes	0.74	○
b) Congruent figures and similar triangles	0.85	○
c) Relationship between three-dimensional and their two-dimensional representations	0.87	○
d) Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	0.85	○
e) Points on the Cartesian plane	0.89	○
f) Translation, reflection, and rotation	0.87	○
Data and change (3 sub-topics)	**Ø**	**Symbol**
a) Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	0.04	○
b) Interpreting data sets (e.g., draw conclusions, make predictions, and estimate values between and beyond given data points	0.68	○
c) Judging, predicting, and determining the chances of possible outcomes	0.79	○
Overall congruent coefficient	**0.70**	○

RMSD			
Countries	**Norway**	**South Africa**	**Index**
Before comparison	Actual input target	Original comparison matrix	0.97
After comparison	Orthogonalised target	Maximally congruent comparison matrix	0.77

It is clear from the results that all the congruent coefficients for the mathematics content coverage activities yielded values that were below 0.95 between teachers in Norway and their counterparts in South Africa. The results indicate that there are no significant similarities about the preparedness of teachers to teach *numbers, algebra, geometry* and *data and change*. Furthermore, the overall congruent coefficient regarding the content coverage (0.70) is lower than the required threshold. The overall results signify that no significant similarities were found overall between the two countries with regards to the teaching of specific mathematics content.

5.8.2 Similarities between Sweden and South Africa

Table 5:19 presents the congruent coefficients between *Swedish* and *South African* learners who were taught by teachers who responded to questions relating to their preparedness to teach specific mathematics content.

Table 5:19 Congruent coefficients between Sweden and South Africa

Mathematics topics		
Numbers (5 sub-topics)	**Ø**	**Symbol**
a) Computing, estimating, or approximating with whole numbers	0.42	○
b) Concepts of fractions and computing with fractions	0.90	○
c) Concepts of decimals and computing with decimals	0.32	○
d) Representing, comparing, ordering, and computing with integers	0.68	○
e) Problem solving involving percentages and proportions	0.49	○
Algebra (5 sub-topics)		
a) Numeric, algebraic, and geometric patterns or sequences	0.80	○
b) Simplifying and evaluating algebraic expressions	0.76	○
c) Simple linear equations and inequalities	0.00	○
d) Simultaneous (two variables equations)	0.99	●
e) Representation of functions as ordered pairs, tables, graphs, words, or equations	0.88	○
Geometry (6 sub-topics)	**Ø**	**Symbol**
a) Geometric properties of angles and geometric shapes	0.48	○
b) Congruent figures and similar triangles	0.97	●
c) Relationship between three-dimensional and their two-dimensional representations	0.52	○
d) Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	0.61	○
e) Points on the Cartesian plane	0.95	●
f) Translation, reflection, and rotation	0.83	○
Data and change (3 sub-topics)	**Ø**	**Symbol**
a) Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	0.72	○
b) Interpreting data sets (e.g., draw conclusions, make predictions, and estimate values between and beyond given data points	0.70	○
c) Judging, predicting, and determining the chances of possible outcomes	0.43	○
Overall congruent coefficient	**0.66**	○

Mathematics topics			
RMSD			
Countries	**Sweden**	**South Africa**	**Index**
Before comparison	Actual input target	Original comparison matrix	0.90
After comparison	Orthogonalised target	Maximally congruent comparison matrix	0.83

It is clear from the results that the congruent coefficients for sixteen of the mathematics content coverage activities yielded values that are below 0.95 between teachers in South Africa and their Saudi Arabian counterparts. Furthermore, the overall congruent coefficient of 0.66 regarding the content coverage is lower than the required threshold. The results indicate that no significant similarities were found overall about the preparedness of teachers to teach *numbers, algebra, geometry* and *data and change* to their learners between the two countries.

In contrast, three items yielded congruent coefficients that were above the required threshold of 0.95. The items were in the following categories, algebra (*simultaneous two variables equations*) and geometry (*congruent figures and similar triangles and points on the Cartesian plane*). The results showed that significant similarities were found between the two countries with regards to the teaching of specific mathematics content to the sampled learners.

5.8.3 Similarities between Saudi Arabia and South Africa

Table 5:20 presents the congruent coefficients between *Saudi Arabian* and *South African* learners who were taught by teachers who responded to questions relating to their preparedness to teach specific mathematics content.

Table 5:20 Congruent coefficient between Saudi Arabia and South Africa

Mathematics topics		
Numbers (5 sub-topics)	**Ø**	**Symbol**
a) Computing, estimating, or approximating with whole numbers	0.89	○
b) Concepts of fractions and computing with fractions	0.45	○
c) Concepts of decimals and computing with decimals	0.41	○
d) Representing, comparing, ordering, and computing with integers	0.50	○
e) Problem solving involving percentages and proportions	0.16	○
Algebra (5 sub-topics)	**Ø**	**Symbol**
a) Numeric, algebraic, and geometric patterns or sequences	0.95	●

b)	Simplifying and evaluating algebraic expressions	0.64	○
c)	Simple linear equations and inequalities	0.91	○
d)	Simultaneous (two variables equations	0.80	○
e)	Representation of functions as ordered pairs, tables, graphs, words, or equations	0.33	○
Geometry (6 sub-topics)		**Ø**	**Symbol**
a)	Geometric properties of angles and geometric shapes	0.38	○
b)	Congruent figures and similar triangles	0.33	○
c)	Relationship between three-dimensional and their two-dimensional representations	0.75	○
d)	Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	0.08	○
e)	Points on the Cartesian plane	0.67	○
f)	Translation, reflection, and rotation	0.70	○
Data and change (3 sub-topics)		**Ø**	**Symbol**
a)	Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	0.74	○
b)	Interpreting data sets (e.g., draw conclusions, make predictions, and estimate values between and beyond given data points	0.58	○
c)	Judging, predicting, and determining the chances of possible outcomes	0.64	○
Overall congruent coefficient		**0.57**	○
RMSD			
Countries	**Saudi Arabia**	**South Africa**	**Index**
Before comparison	Actual input target	Original comparison matrix	0.79
After comparison	Orthogonalised target	Maximally congruent comparison matrix	0.97

It is clear from the results that the congruent coefficients for almost all the mathematics content coverage activities yielded values that were below 0.95 between teachers in South Africa and their Saudi Arabian counterparts. The results indicate that there are no significant similarities about the preparedness of teachers to teach *numbers, algebra, geometry* and *data and change* to their learners*.* The overall congruent coefficient of 0.57 regarding the content coverage (0.57) is lower than the required threshold. The overall congruent coefficient, which is lower than the required threshold, suggests that no significant similarities were found overall between the two countries with regards to the teaching of specific mathematics content to the sampled learners.

In contrast, only one item in algebra (*numeric, algebraic and geometric patterns or sequences*) yielded a congruent coefficient that was above the required threshold. The congruent coefficient computed for the one item suggested that significant similarity was found between the two countries with regards to the teaching of specific mathematics content to the sampled learners, namely numeric, algebraic, and geometric patterns or sequences (Algebra).

5.8.4 Similarities between Thailand and South Africa

Table 5:21 presents the congruent coefficients between *Thai* and *South African* learners who were taught by teachers who responded to questions relating to their preparedness to teach specific mathematics content.

Table 5:21 Congruent coefficients between Thailand and South Africa

Mathematics topics			
Numbers (5 sub-topics)		**Ø**	**Symbol**
a)	Computing, estimating, or approximating with whole numbers	0.70	○
b)	Concepts of fractions and computing with fractions	0.56	○
c)	Concepts of decimals and computing with decimals	0.59	○
d)	Representing, comparing, ordering, and computing with integers	0.78	○
e)	Problem solving involving percentages and proportions	0.55	○
Algebra (5 sub-topics)		**Ø**	**Symbol**
a)	Numeric, algebraic, and geometric patterns or sequences	0.85	○
b)	Simplifying and evaluating algebraic expressions	0.81	○
c)	Simple linear equations and inequalities	0.70	○
d)	Simultaneous (two variables equations	0.72	○
e)	Representation of functions as ordered pairs, tables, graphs, words, or equations	0.94	○
Geometry (6 sub-topics)		**Ø**	**Symbol**
a)	Geometric properties of angles and geometric shapes	-0.14	○
b)	Congruent figures and similar triangles	0.28	○
c)	Relationship between three-dimensional and their two-dimensional representations	0.67	○
d)	Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	0.15	○
e)	Points on the Cartesian plane	0.78	○
f)	Translation, reflection, and rotation	0.49	○
Data and change (3 sub-topics)		**Ø**	**Symbol**
a)	Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	0.85	○
b)	Interpreting data sets (e.g., draw conclusions, make predictions, and estimate values between and beyond given data points	0.83	○
c)	Judging, predicting, and determining the chances of possible outcomes	0.86	○
Overall congruent coefficient		**0.63**	○

RMSD			
Countries	**Thailand**	**South Africa**	**Index**
Before comparison	Actual input target	Original comparison matrix	0.91
After comparison	Orthogonalised target	Maximally congruent comparison matrix	0.86

It is clear from the results that all the congruent coefficients for the mathematics content coverage activities yielded values that were below 0.95 between teachers in Thailand and their South African counterparts. The results indicate that there are no significant similarities about the preparedness of teachers to teach *numbers, algebra, geometry* and *data and change*. Furthermore, the value of the overall congruent coefficient results regarding the content coverage (0.63) is lower than the required threshold. The overall results show that no significant similarities were found overall between the two countries with regards to the teaching of specific mathematics content.

5.8.5 Similarities between Singapore and South Africa

Table 5:22 presents the congruent coefficients between *Singaporean* and *South African* learners who were taught by teachers who responded to questions relating to their preparedness to teach specific mathematics content.

Table 5:22 Congruent coefficients between Singapore and South Africa

Mathematics topics		
Numbers (5 sub-topics)	**Ø**	**Symbol**
a) Computing, estimating, or approximating with whole numbers	0.64	○
b) Concepts of fractions and computing with fractions	0.12	○
c) Concepts of decimals and computing with decimals	0.60	○
d) Representing, comparing, ordering, and computing with integers	0.91	○
e) Problem solving involving percentages and proportions	0.31	○
Algebra (5 sub-topics)	**Ø**	**Symbol**
a) Numeric, algebraic, and geometric patterns or sequences	0.57	○
b) Simplifying and evaluating algebraic expressions	0.34	○
c) Simple linear equations and inequalities	0.72	○
d) Simultaneous (two variables equations	0.26	○
e) Representation of functions as ordered pairs, tables, graphs, words, or equations	0.45	○
Geometry (6 sub-topics)	**Ø**	**Symbol**
a) Geometric properties of angles and geometric shapes	0.52	○
b) Congruent figures and similar triangles	0.83	○
c) Relationship between three-dimensional and their two-dimensional representations	0.26	○
d) Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	0.52	○
e) Points on the Cartesian plane	0.65	○
f) Translation, reflection, and rotation	0.67	○
Data and change (3 sub-topics)	**Ø**	**Symbol**
a) Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	0.93	○

Mathematics topics				
b) Interpreting data sets (e.g., draw conclusions, make predictions, and estimate values between and beyond given data points			0.18	○
c) Judging, predicting, and determining the chances of possible outcomes			0.56	○
Overall congruent coefficient			**0.53**	○
RMSD				
Countries	**Singapore**	**South Africa**	**Index**	
Before comparison	Actual input target	Original comparison matrix	0.79	
After comparison	Orthogonalised target	Maximally congruent comparison matrix	0.97	

The results reveal that all the content coverage activities generated congruent coefficient values below 0.95 between Singapore and South Africa. Therefore, it can be deduced from the results that there is lack of significant similarities between South African and Singaporean teachers about the preparedness of teachers to teach *numbers*, *algebra*, *geometry* and *data and change*. Similarly, the value of the overall congruent coefficient results regarding the content coverage of 0.53 is lower than the required threshold. The overall congruent coefficient calculated suggests that no significant similarities were found overall between the two countries with regards to the teaching of specific mathematics content. It can be deduced that the intervention did not yield the expected results.

5.8.6 Similarities between United Arab Emirates and South Africa

Table 5:23 presents the congruent coefficients between the *United Arab Emirates* and *South African* learners who were taught by teachers who responded to questions relating to their preparedness to teach specific mathematics content.

Table 5:23 Congruent coefficients between the United Arab Emirates and South Africa

Mathematics topics		
Numbers (5 sub-topics)	**Ø**	**Symbol**
a) Computing, estimating, or approximating with whole numbers	0.29	○
b) Concepts of fractions and computing with fractions	0.79	○
c) Concepts of decimals and computing with decimals	0.17	○
d) Representing, comparing, ordering, and computing with integers	0.46	○
e) Problem solving involving percentages and proportions	0.34	○
Algebra (5 sub-topics)	**Ø**	**Symbol**
a) Numeric, algebraic, and geometric patterns or sequences	0.64	○
b) Simplifying and evaluating algebraic expressions	0.90	○
c) Simple linear equations and inequalities	0.39	○
d) Simultaneous (two variables equations	0.66	○

Mathematics topics		
e) Representation of functions as ordered pairs, tables, graphs, words, or equations	0.77	○
Geometry (6 sub-topics)	**Ø**	**Symbol**
a) Geometric properties of angles and geometric shapes	0.23	○
b) Congruent figures and similar triangles	0.58	○
c) Relationship between three-dimensional and their two-dimensional representations	0.68	○
d) Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	0.43	○
e) Points on the Cartesian plane	0.90	○
f) Translation, reflection, and rotation	0.92	○
Data and change (3 sub-topics)	**Ø**	**Symbol**
a) Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	0.83	○
b) Interpreting data sets (e.g., draw conclusions, make predictions, and estimate values between and beyond given data points	0.70	○
c) Judging, predicting, and determining the chances of possible outcomes	0.86	○
Overall congruent coefficient	0.61	○

RMSD			
Countries	**United Arab Emirates**	**South Africa**	**Index**
Before comparison	Actual input target	Original comparison matrix	0.91
After comparison	Orthogonalised target	Maximally congruent comparison matrix	0.89

The results reveal that all the content coverage activities generated congruent coefficients below the acceptable threshold of 0.95 between the United Arab Emirates teachers and their South African counterparts. Therefore, it can be deduced that there are no significant similarities between South Africa and the United Arab Emirates about the preparedness of teachers to teach *numbers*, *algebra*, *geometry* and *data and change*. Similarly, the overall congruent coefficient of 0.61 regarding the content coverage is lower than the required threshold. The overall congruent coefficient calculated suggests that no significant similarities were found overall between the two countries with regards to the teaching of specific mathematics content.

5.8.7 Summary of similarity results about content coverage

Table 5:24 shows the summary of the similarity results between South Africa and each of the countries analysed in this study.

Table 5:24 Summary of specific content coverage

Mathematics topics		Congruent coefficients between South Africa and each of the countries compared with					
Numbers (5 sub-topics)		**NOR**	**SWE**	**SAU**	**THA**	**SGP**	**UAE**
a)	Computing, estimating, or approximating with whole numbers	0.62	0.62	0.89	0.70	0.64	0.29
b)	Concepts of fractions and computing with fractions	0.54	0.54	0.45	0.56	0.12	0.79
c)	Concepts of decimals and computing with decimals	0.39	0.39	0.41	0.59	0.60	0.17
d)	Representing, comparing, ordering, and computing with integers	0.57	0.57	0.50	0.78	0.91	0.46
e)	Problem solving involving percentages and proportions	0.69	0.69	0.16	0.55	0.31	0.34
Algebra (5 sub-topics)		**NOR**	**SWE**	**SAU**	**THA**	**SGP**	**UAE**
a)	Numeric, algebraic, and geometric patterns or sequences	0.71	0.80	0.95	0.85	0.57	0.64
b)	Simplifying and evaluating algebraic expressions	0.80	0.76	0.64	0.81	0.34	0.90
c)	Simple linear equations and inequalities	0.67	0.00	0.91	0.70	0.72	0.39
d)	Simultaneous (two variables equations	0.90	0.99	0.80	0.72	0.26	0.66
e)	Representation of functions as ordered pairs, tables, graphs, words, or equations	0.85	0.88	0.33	0.94	0.45	0.77
Geometry (6 sub-topics)		**NOR**	**SWE**	**SAU**	**THA**	**SGP**	**UAE**
a)	Geometric properties of angles and geometric shapes	0.74	0.48	0.38	-0.14	0.52	0.23
b)	Congruent figures and similar triangles	0.85	0.97	0.33	0.28	0.83	0.58
c)	Relationship between three-dimensional and their two-dimensional representations	0.87	0.52	0.75	0.67	0.26	0.68
d)	Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	0.85	0.61	0.08	0.15	0.52	0.43
e)	Points on the Cartesian plane	0.89	0.95	0.67	0.78	0.65	0.90
f)	Translation, reflection, and rotation	0.87	0.83	0.70	0.49	0.67	0.92
Data and change (3 sub-topics)		**NOR**	**SWE**	**SAU**	**THA**	**SGP**	**UAE**
a)	Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	0.04	0.72	0.74	0.85	0.93	0.83
b)	Interpreting data sets (e.g., draw conclusions, make predictions, and estimate values between and beyond given data points	0.68	0.70	0.58	0.83	0.18	0.70
c)	Judging, predicting, and determining the chances of possible outcomes	0.79	0.43	0.64	0.86	0.56	0.86
Overall congruent coefficient		**0.70**	**0.66**	**0.57**	**0.63**	**0.53**	**0.61**
Saudi Arabia (SAU), SWE (Sweden), NOR (Norway), THA (Thailand), UAE (United Arab Emirates) and SGP (Singapore).							

The overall results revealed that there were insignificant similarities between learners in South Africa and their international counterparts regarding how well prepared teachers felt about teaching numbers, algebra, geometry, data and change curriculum topics. It is clear from the results that there are different views about how teachers felt in terms of teaching numbers, algebra, geometry, data and change to their learners. Based on the results it can be inferred that there is no significant similarity between South Africa and their international counterparts after the data has been modelled using the orthogonal rotational technique.

However, these countries have all performed better than South Africa when it comes to learner achievements. Therefore, in order to address the challenges of teaching these topics, intervention strategies should be put in place. The envisaged capacity building interventions where South Africans can learn from the international counterparts, could be considered even though we found no significant similarities. Furthermore, communities of practice should be established so that teachers can be afforded an opportunity to learn from each other. However, it should be noted that communities of practice should be developed on a mutual understanding between teachers in South Africa and each of these countries.

5.9 Conclusion

This chapter presented the findings and the analysis of the study grounded in the data that was acquired from the TIMSS 2011 dataset. Secondly, the factor models used in each question were presented based on the eigenvalues, KMO values and the Bartlett test. The KMO values of the teachers' responses were above 0.5, and the p-value of Barlett's Test was less than 0.001, which proved to be significant in the analyses carried out. In light of these results, the data used in this study was appropriate for the factor analysis technique. Furthermore, the inferential statistics were presented based on the statistical analysis used in the study, namely factor analysis, orthogonal rotation, as well as congruent coefficient. Lastly, for each question the congruent coefficient was used to determine the similarities between South Africa and each of the countries analysed in this study.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

The research questions were divided into three key concepts to address the research aims of this study. The results noted during this research and the recommendations concerned, are detailed below.

This chapter starts by reminding the reader of the importance of comparative studies and the rationale of the study, after which it will reflect on the literature review, the research methodology and the TPACK framework as it was used in this research. In addition, it outlines the outcomes of each research question, as well as lessons that can be learned from this study. Finally, recommendations for further research and policy making are also presented.

6.2 The importance of comparative studies

Stigler, Gallimore, and Heibert (2000, p. 87), indicated that if

> *cross-national achievement differences are tied to cultural variations in teaching, we may discover ways of teaching that work better than the ones our society routinely employs. This would allow us to take advantage of the experience of others all over the world who shares similar goals* (Stigler et al. (2000, p. 87)*.*

Borrowing from Stigler et al. (2000, p. 87), the phrase “who share similar goals” is the most important expression that can be regarded as the essential yardstick against which the realisation of a country’s classroom practices are evaluated. Furthermore, LeTendre, Baker, Akiba, Goesling, and Wiseman (2001, p. 3) pointed out that “we find some differences in how teachers’ work is organised, but similarities in teachers’ belief patterns.” It is imperative for policy makers to be aware of teachers’ ways of thinking, because this may inform pre-service and on-going teacher professional development activities, as well as curricular transformation agendas.

6.3 Rationale of the study

In this thesis, the emphasis was on a cross-country comparison of mathematics teachers' beliefs about technology, pedagogy and content knowledge. Therefore, the rationale of this investigation was to determine how South African learners compared with their selected international counterparts according to their teachers' viewpoints. The comparison was based on the teachers' self-reported views that were linked to learners' data expressed during the TIMSS 2011 study. This study was also driven by the prevailing notion that the achievements of South African learners, who participated in the TIMSS 2011 assessment, were below average as when compared to other countries.

Furthermore, the TIMSS 2011 results have shown that the mathematics achievements of learners in the six countries analysed in this study (Norway, Sweden, Saudi Arabia, Thailand, Singapore and United Arab Emirates) are outperforming South Africa. This study is the analysis of the TIMSS 2011 dataset, the fifth trend measure conducted by IEA since 1995.

6.4 Literature review

This section reminds the reader of what could be learned from the literature review relating to the TIMSS international comparative studies, teachers' belief systems as well as the TPACK framework used in this study.

6.4.1 TIMSS comparative studies

White (1987) as quoted by Watanabe (2001, p. 201) stated that policy makers and researchers can use well performing countries as a reflection "but not as a blueprint." This author, Watanabe (2001), argues that well performing countries can serve as a reference to other countries based on the results arising from the TIMSS international comparative studies. The most imperative attribute is for underperforming countries to learn from well-performing countries when conducting a reflection of their own practices. The emphasis should be placed on the development of intervention plans, and not with the intensions of replicating well- performing countries practices. Therefore, the cross-country comparative studies have the ability to unearth, and spell out, not only the similarities and variations in policy and practice, but the association between these rapports and variations (Grønmo & Onstad, 2013; Mullis et al., 1997; Murphy, 2010).

6.4.2 Teachers' beliefs system

A number of studies classified teachers' beliefs into two distinct categories, namely constructivism or behaviourism (Lepik & Pipere, 2011; Mansour, 2009). It has been argued that researchers and policy makers should understand these underlying theoretical issues that underpin teachers beliefs' about the integration of technology into teaching and learning. A frequent deduction in the literature is that transforming teachers' beliefs is a complicated and mysterious process (Handal, 2003; Prawat, 1992). In addition, several exploratory studies have been carried out to determine teachers' thinking that is associated with the manner in which they accept the use of educational technology, or fail to utilise it as part of their classroom practices (Hannafin & Freeman, 1995; Olech, 1997). In order to change teachers' belief systems, they should be supported in their endeavour to integrate technology into teaching and learning. Furthermore, it is imperative for teachers to change their belief system in order to embrace new practices and to thus infuse educational technology into teaching and learning.

6.4.3 TPACK conceptual framework

Mishra and Koehler (2006) developed a conceptual framework named TPACK by enhancing Shulman's idea of ''pedagogical content knowledge'' and broadened it to the phenomenon of teachers integrating digital technologies into their pedagogy. The TPACK framework consists of two forms of knowledge namely, primary and secondary knowledge. The primary forms of knowledge encompass content, pedagogy and technology. The technological pedagogic knowledge, technological content knowledge and pedagogical content knowledge are regarded as the secondary forms of knowledge. Furthermore, at the heart of these two forms of knowledge is the TPACK. The TPACK framework envisioned a teacher who is capable of incorporating knowledge of technology, content and pedagogy into their teaching and learning practices (Mishra & Koehler, 2006).

Therefore, in order to make sure that the effects of mathematics teaching are accomplished, it is vital that mathematics teachers are able to understand and embrace the TPACK framework. This framework has the potential of deepening teachers' classroom experiences.

Researchers have pointed out a number of factors that are the stumbling blocks in relation to why the introduction of technological devices has not transformed classroom practices (Graham, 2011; Howey & Grossman, 1989; Niess, 2005). The non-availability of customised educational subject-specific professional development courses that focus on the integration of technology into different subject areas, is regarded as one of these hindrances (Niess, 2005). The training of teachers on how to integrate technology as part of their classroom practice is also regarded as one of the hindrances impacting the use of computers in education. Furthermore, the underutilisation of computers has been noticeable for some time and still continues to be an international issue (Abrami, 2001; Muir-Herzig, 2004; Sutherland et al., 2004).

However, policy makers and researchers are aware that integration of technology into classroom practices brings about the relationship between classroom instructions, teachers, learners, technology and the content that has to be taught.

6.5 Research questions used in the study

It should be noted that the sampling, for the teachers who completed the questionnaire, was based on the participating learners. Therefore, it is important to note that in this thesis the learners were always the unit of analysis even if the information from the teachers' questionnaire were reported. The three research questions that formed part of the study were as follows:

Research Question 1: How do South African learners compare with their selected international counterparts with regards to their teachers' use of various **computer activities**?

Research Question 2: How do South African learners compare with their selected international counterparts with regards to their teachers' use of different **teaching strategies**?

Research Question 3: How do South African learners compare with their selected international counterparts with regards to their teachers' preparedness to teach **specific mathematics content**?

To explore these questions, the congruent coefficient was used to determine the similarities between learners in South Africa and each of the selected international counterparts.

6.6 Discussion of the research findings

The learners data analysed in this study were linked to their teachers responses which were extracted from the TIMSS 2011 teacher questionnaire. The descriptive and the inferential statistics analysed in this research are outlined in the subsequent paragraphs.

6.6.1 Descriptive statistics

The empirical strategies began with the analysis of the descriptive data obtained from the TIMSS 2011 dataset, identifying patterns and differences across countries. The descriptive statistics analysed in the study included *population, biographical information, use of computers, mathematical resources* and *sampled schools*.

Furthermore, teacher characteristics were analysed using the percentages of learners that were taught by teachers who provided their personal view. The following items were selected: *gender, age, the teacher's educational qualification in mathematics* and the *use of computers* by teachers and learners according to teachers' responses.

(a) Socio-economic status

The government expenditure on education index was used as a control variable to select all the countries with values close to that of South Africa. Therefore, based on the government expenditure on education index, a total of seven countries including South Africa were selected and analysed in this study. There were three countries with a higher and three countries with a lower government expenditure on education than that of South Africa.

It should be noted that the government expenditure on education of all the countries analysed in this study also varies slightly with that of South Africa. The countries with the higher government expenditure on education were Norway and Sweden, with a value of 7 percent, while the United Arab Emirates, had the lowest value (1%).

The results revealed that regardless of the differences in the socio-economic status between South Africa and each of the countries in this study, it could still be claimed that some similarities were found. In this study, similarity did not imply being totally identical, but rather demonstrated which responses might have a similar structure after the statistical analysis.

(b) Population and sampled schools

The results from the analysis revealed that the number of sampled schools in 71% of the countries were higher than the TIMSS sampling strategy of 150 schools. In contrast, Norway (134) and Singapore (145) had the lowest number of sampled schools. The lowest number of schools in these two countries had no effect on the analysis of data. It should be noted that the results of the TIMSS analysis are not based on the number of sampled schools, but rather on the number of learners who were taught by teachers who completed the teacher questionnaire.

(c) Biographical information

This section outlines the biographical variables that were selected from the TIMSS 2011 Grade 8 teachers questionnaire and analysed in this study.

Teachers' reports on their gender distribution

The results from the analysis revealed that 54% of the sampled mathematics learners were taught by female teachers in all seven countries analysed in this study. These results indicated a slight dominance of females in 57% of the countries sampled in this study (Sweden, Thailand, United Arab Emirates and Singapore). In contrast, there are notable exceptions in South Africa and Norway where 56% of learners in each country were taught by male teachers.

Teachers' reports on their age categories

The results found that the country that had the highest percentage of learners (36%), who were taught by teachers between the age category of 40-49, was South Africa. A different pattern showed that 3% of the sampled mathematics learners were taught by teachers below the age of 25 and those aged 60 years and above, in all the countries analysed in this study. This notion is supported by the Human Science Research Council (2003) which indicated that the low number of mathematics teachers who are entering the teaching profession is concerning. The results revealed that there seems to be a need to recruit more young people to take up teaching as a career and to specialise in mathematics specifically, because of the aging workforce.

The high number of experienced mathematics teachers, who are on the verge of leaving the teaching profession, presents a challenging picture in all the countries analysed in this study. Especially if one takes into account that a number of empirical studies indicated that a significant and positive non-linear relationship could be found between the experience of teachers and student achievement (Greenmwald, Hedges, & Laine, 1996; Rice, 2003).

(d) Teachers' reports on their mathematics qualifications

The teachers' qualifications were looked into in relation to mathematics and education mathematics as the main areas of study. The study found that the average number of the learners (71%) in all the countries analysed in this study were taught by teachers who studied mathematics. However, in South Africa, 80%

of the learners were taught by these teachers, but this did not seemingly make a positive impact on the performance of South African learners.

The results revealed that 40% (average number) of the learners were taught by teachers who studied and majored in education mathematics. In South Africa, 39% of learners where taught by teachers who studied education mathematics. It is evident from the results that a mathematics qualification is not the only hindrance that influences the performance of learners in mathematics. The major challenge is for policy makers in South Africa to determine which mathematics qualification between education mathematics and mathematics, is most appropriate for its teachers and further research into this matter is therefore called upon. We can speculate that the low level of learner performance in South Africa might not necessarily be attributed to mathematics qualifications of the teachers.

(e) Teachers' reports on their use of computers

The statistics revealed that learners are taught by teachers who used digital technologies such as computers for lesson preparation (79%), administration (80%) as well as instruction (67%) in all the countries analysed in the study. However, South African teachers (41%) seem to lag behind the other countries in the study in that fewer of them used computers for lesson preparation purposes. The results thus highlight the differences that exist in these countries regarding the allocation and use of computers by teachers. Furthermore, the results further revealed that fewer South African learners are taught by teachers who are using computers for teaching and learning (31%) when compared to the international counterparts analysed in this study.

Curry (2000) and Herther (1997) indicated that the digital divide is often regarded as a problem relating to access to technology. However, access is only the initial obstacle but once it is achieved, there are still other challenges such as usage and maintenance. These challenges highlight the need for the training of teachers in the application of technology in developing countries. The challenges experienced might include the provisioning of computers, teacher training on the use of computers and the provisioning of relevant mathematics software. Future research is thus required.

(f) Teachers' reports on the use of computers by their learners

The statistics revealed that more learners in South Africa were taught by teachers who indicated that they have "never or almost never" allowed their learners to use computer activities to explore mathematical principles and concepts (70%), practise skill and procedures (72%) and process and analyse data (66%), than their international counterparts. The deduction that can be reached from these results is that there are challenges that mathematics teachers in South Africa are experiencing with regards to the integration of computers into teaching and learning. The challenges faced might include the provisioning of computers, teacher training on the use of computers and the provisioning of relevant mathematics software. Furthermore, teachers might still be using traditional teaching practices and they might not yet have embraced the 21st century teaching and learning strategies that incorporate the use of digital technologies. It can be concluded that regardless of the procurement of these digital resources, the results in this study revealed disparities regarding the impact of these technologies in the classroom instructions in South African schools. Therefore, future research is required.

6.6.2 Inferential statistics

This section outlines the summary results for each research question. The outcomes and the inferences of this study can be used to make judgements about the entire population of learners, even those who were not part of this study or the TIMSS 2011 study.

The findings of the TIMSS 2011 were generalised to the entire population of Grade 9 learners in South Africa and where relevant, the Grade 8 learners in all the countries that participated in the investigation. However, it has been argued by various researchers (Misco, 2007; Polit & Beck, 2010; Robinson & Norris, 2001) that the onus of generalising the findings of a study such as the one upon which this thesis is based, rests with the readers, policy makers and other researchers.

The sampling technique utilised during the TIMSS investigation, assured that learner samples were representative countrywide, but it is important to note that teachers' samples were not. The selected responses from the teachers' questionnaire were as follows, *use of computers* by teachers and learners, *teaching strategies*, and *preparedness to teach specific mathematics topics*. Therefore, the results could only be used to explore the views of the teachers who provided their inputs in relation these three responses, namely *use of computers by teachers and learners, teaching strategies* as well as their *preparedness to teach specific mathematics topics*.

In this study three models were developed and validated to determine how South African learners compared with their international counterparts. Furthermore, these three topics were selected based on the TPACK theoretical framework used in the study. The factor analysis retained two factors for *computer activities*, three factors for *teaching strategies* and five factors for *preparedness to teach specific mathematics content*, respectively. The comparison was based on the three research questions outlined in the subsequent section. The findings showed that the South African models of learners, based on their teachers' beliefs, behaved somehow similarly to that of their international counterparts based on their responses.

(a) Research question 1: Computer activities

How do South African learners compare with their selected international counterparts with regards to their use of **computer activities**?

Mathematics teachers were asked to state whether they use computers to accomplish specific mathematics tasks. There were seven statements that were listed as part of the question (see Annexure C).

Table 6:1 presents a summary of the results regarding the use of computer activities between South Africa and each of the countries analysed in this study.

Table 6:1: Use of computer activities

Countries	South Africa			
	Number of statement(s) with congruent coefficient(s)		Overall results	
	< 0.95	≥ 0.95	Negative	Positive
Norway	1	6	Yes	-
Sweden	1	6	-	Yes
Saudi Arabia	1	6	-	Yes
Thailand	1	6	-	Yes
Singapore	1	6	-	Yes
United Arab Emirates	1	6	Yes	-
		Overall percentage	33%	67%

The results showed similarities between learners in South Africa and their selected international counterparts in terms of how they used different computer activities based on their teachers' reports. Significant similarities were found in 67% of the statements between South Africa and the countries analysed in this study.

The *overall* consolidated teachers' results revealed that there were significant similarities between South African learners and their selected international counterparts in Saudi Arabia, Sweden, Thailand and Singapore who have all used different computer activities in their mathematics classrooms. The results of this study showed that South African learners do compare with their counterparts (Saudi Arabia, Sweden, Thailand and Singapore) regarding how their teachers have used computer activities. As all of the other countries' learners outperformed the South African learners in terms of academic performance, it would make sense for the Department of Basic Education to explore ways to learn from best practices in these countries (see Table 6:2).

It is imperative for teachers to have knowledge and skills about how they can use and integrate technology into teaching and learning. However, the details of the intervention should be made known to teachers in South Africa, as well as their international counterparts. According to Bracey (1993), the introduction of computers into teaching and learning is believed to have a bearing on the role of teachers as well as shifting their beliefs from a didactic to a constructivist approach.

(b) Research Question 2: Teaching strategies

How do South African learners compare with their selected international counterparts with regards to how their teachers have used different **teaching strategies**?

Mathematics teachers were asked to provide their views on whether they use specific teaching strategies to accomplish specific mathematics tasks. Teachers provided responses to the eleven statements that were listed as part of this question (see Annexure D). Learners' data was used to determine the similarities based on the teachers viewpoints between South Africa and each of the countries analysed in this study. Both significant and insignificant similarities were found between South Africa and the countries analysed in this study.

Table 6:2 presents a summary of the results regarding the use of different teaching strategies between South Africa and each of the countries analysed in this study.

Table 6:2 Teaching strategies

Countries	South Africa			
	Number of statement with congruent coefficient(s)		Overall results	
	< 0.95	≥ 0.95	Negative	Positive
Norway	8	3	Yes	-
Sweden	6	5	Yes	-
Saudi Arabia	8	3	Yes	-
Thailand	9	2	Yes	-
Singapore	6	5	Yes	-
United Arab Emirates	8	3	Yes	-
		Overall percentage	100%	

The notion of significant similarities is supported by Mullis and Martin (2006) who stated that teaching and learning strategies employed in mathematics classrooms all over the world are "remarkably similar" (p.21). Statistically significant results found between teachers in South Africa and their international counterparts suggest that there might be a global approach that could be used to reduce achievement gaps based on the socio-economic status.

The results of this study showed that South African learners do not compare with all their counterparts in terms of how their teachers have used different teaching strategies. As all of these other countries' learners outperformed the South African learners in terms of performance, it would make sense to explore ways to learn from best practices in these countries (see Table 5:17). The results might be due to how teachers interpreted the statements across the various countries, which points to a major challenge in any international assessment that uses self-reporting teachers' questionnaires.

Finally, it is clear that intervention strategies should be put in place to support the establishment of the communities of practice for capacity building among teachers, irrespective of their countries of origin. Therefore, it is postulated that mathematics teachers in South Africa might benefit tremendously from learning from their international counterparts about how they have used various innovative teaching strategies in their mathematics classrooms.

(c) Research question 3: Specific mathematics content

How do South African learners compare with their selected international counterparts with regards to teachers' preparedness to teach **specific mathematics content**?

There were five items that were listed as part of the questions that requested teachers to report on their preparedness to teach specific mathematics content (see Annexure E). The chosen variables were *numbers* (five statements), *data and change* (three statements), *algebra* (five statements) and *geometry* (six statements).

Table 6:3 presents a summary of the results regarding teachers' preparedness to teach specific mathematics content between South Africa and each of the countries analysed in this study.

Table 6:3 Specific mathematics content

Countries	South Africa			
	Number of statement with congruent coefficient(s)		Overall results	
	< 0.95	≥ 0.95	Negative	Positive
Norway	19	0	Yes	-
Sweden	19	0	Yes	-
Saudi Arabia	18	1	Yes	-
Thailand	19	0	Yes	-
Singapore	19	0	Yes	-
United Arab Emirates	19	0	Yes	-
		Overall percentage	100%	

The *overall* consolidated results revealed that there were no similarities between South African teachers when compared to all their selected international counterparts with regards to their preparedness to teach specific mathematics content. The results of this study showed that South African learners do not compare with their counterparts in terms of their teachers preparedness to teach specific mathematics content.

Furthermore, the results indicate that the social-economic status of these countries is not the only factor that influences the preparedness of teachers to teach specific content to their mathematics classrooms. Based on the overall results, it is recommended that strategies should be formulated for collaboration between South Africa and its international counterparts. The South African teachers might learn from the international counterparts about how they have taught specific content to their mathematics classrooms (regarding items where the congruent coefficients were higher than the required threshold).

6.7 Methodological reflection

Often investigators find out that it is essential to compare two, or more, factors to determine their similarity and variations (Triola, 2008).

The literature reviewed indicated that factor analysis is regularly used as a data reduction technique for scientific purposes, ranging from data reduction to hypothesis testing (Cohen & Manion, 2007; Field, 2014). The KMO and the Bartlett's test of sphericity values that were obtained, denoted that the selected teacher responses were adequate enough to be used in factor analysis processes.

That said, all the teacher responses that satisfied the Keiser's criterion (eigenvalues ≥ 1) and had acceptable variability values (>= 0.5), were retained. However, based on Keiser's technique a variety of teachers' response models were adopted for each of the research questions analysed in this study. Table 4:1 (in Chapter 4) indicated the models that were used to identify the number of factors to be retained from questions extracted from the teachers' questionnaire. As a result, two factors for computer activities, three factors for teaching strategies and five factors for content coverage, were retained.

Furthermore, the teacher responses extracted from the teacher questionnaire were categorical in nature, therefore CATPCA was used to transform the ordinal data (the teacher responses) derived from them, into quantifiable data. Finally, in this study the congruent coefficient analysis was performed to determine how South African teachers' beliefs compared with their international counterparts. For the purpose of this study the Lorenzo-Seva and ten Berge (2006) cut-off point was adopted and used to determine the similarity between South Africa and the other countries. It should be noted that the Orthosim software used to calculate the congruent coefficients is predominantly used in other disciplines such as psychology. Furthermore, the Orthosim software has not been regularly associated with any of the previous TIMSS investigations and can thus be regarded as an innovation in the field of education.

In terms of data collection, this study used data that was collected during the TIMSS 2011 study. Furthermore, this research was a secondary data analysis using self-reported responses from mathematics teachers, collected using a questionnaire. Teacher self-report data is relatively easy to collect and capture; however it can be riddled with individual teacher bias.. For instance, teachers may not take the survey seriously and complete the survey simply to satisfy the researcher. A proper teacher observation instrument should be developed that may serve as a measure of the teachers' classroom practices.

6.8 Scientific reflection

The research provided a dynamic approach to determine how South African teachers' self-reported beliefs compared with their international counterparts. The outcomes of this study revealed that the underlying characteristics of teachers' beliefs can be statistically matched between different countries. Notably, this study is among the first to examine how South African teachers' beliefs compare with international counterparts using a combination of factor analysis, CATPCA and congruent coefficient statistical techniques.

Ideally this study will help future researchers by making known a valuable statistical technique for comparing cross-sectional data. In addition to examining the dynamics and similarities between teachers' belief systems across countries, this study also created three models that can be used by other researchers interested in comparing self-reported beliefs. Lastly, it was through the data modelling process that this investigation was able to establish the variations and similarities.

6.9 Recommendations for policy and further research

This section outlines the recommendations for policy and further research.

6.9.1 Recommendation for policy

The results of this study suggest that policy makers should be aware of the unique differences that exist in the education systems, especially teachers' beliefs in the teaching of mathematics. These differences could explain why the learners in the other countries in the study outperformed South African learners even though the countries were seemingly comparable in terms of their teachers' use of computer activities.

Furthermore, the current study has shown that teaching and learning strategies, as well as the current use of computers in education, are somehow alike among the countries selected for this study. Therefore, the specific characteristics of learning strategies, the use of computer activities and content coverage in each of the participating countries should be assessed in more detail, in order for South African learners to benefit from the best practices elsewhere.

Furthermore, it is also imperative for policy makers to provide relevant and appropriate resources such as computers and interactive software for teaching and learning. The provisioning of resources such as computers and the installation of relevant mathematics software, could possibly be one of the interventions that could be implemented in South Africa.

The training of teachers with regards to how technology can be infused into teaching and learning, might be another aspect that could be pursued. In terms of this aspect the results given by the congruent coefficients of the study were extremely uneven, especially on the use of various teaching strategies and how teachers felt about teaching specific mathematics topics. As such, in South Africa particularly, the government would do well if they could develop pre- and in-service subject-specific technology teacher training programmes. Teachers would obviously benefit from being trained on how to integrate ICT into teaching and preferably learning, using the TPACK framework. The envisaged training should preferably be subject-specific, so that teachers will acquire the skills required to teach their speciality in a 21st century classroom. It has been deduced that teachers' way of thinking could be best adapted when they are engaged in a process that requires them to change their attitudes, to take risks when they are confronted with uncertainty (Dwyer et al., 1991).

6.9.2 Recommendations for further research

It is important for well- and underperforming countries to collaborate to put mathematics programmes in place that are aimed at improving learners' performance globally. Once these programmes have been put in place, further investigation will be required to determine whether the effects of these programmes yield the same results in different parts of the world. The proposed investigation should also determine if the same outcomes can be observed for learners in South Africa after the interventions. More research may also be conducted since the results given by the congruent coefficients were extremely uneven, especially in terms of the use of various teaching strategies and how teachers felt about teaching specific mathematics topics.

6.10 Limitations

In terms of data collection, this study used data that was collected during the TIMSS 2011 study. Thus, this research was a secondary analysis using self-reported responses from mathematics teachers collected using a questionnaire. Although teacher self-report data is relatively easy to collect and capture, it can be riddled with individual teacher bias. For instance, teachers may not take the survey seriously and complete the survey simply to satisfy the researcher.

6.11 Conclusion

The results tended to confirm the existence of similar use of computer activities and teaching strategies in teaching and learning held by mathematics teachers from different countries. At the same time the results showed no similarities with some of the countries, possibly due to the differences in their socio-economic background and uniquely different educational systems.

The fact that government spending alone is not a reason for non-performance in mathematics, as we see that countries that have slightly higher and slightly lower government expenditure on education than South Africa outperformed South Africa in all cases. However, we found that there were similarities between South Africa and the other countries in quite a number of areas and that these similarities indicate the sectors where we can learn from them.

"Success is not how high you have climbed, but how you make a positive difference to the world." Roy T. Bennett.

LIST OF REFERENCES

Abel, R. (2007). Innovation, adoption and learning impact: Creating the future of IT. *Educause Review, 42*(2), 12-30.

Abrami, P. C. (2001). Understanding and promoting complex learning using technology. *Educational Research Evaluation*(7), 113–136.

Agarwal, R., & Prasad, J. (1998). A conceptual and operational definition of personal innovativeness in the domain of information technology. *Information Systems Research, 9*(2), 204-215.

Akiba, M., LeTendre, G. K., & Scribner, J. P. (2007). Teacher Quality, Opportunity Gap, and National Achievement in 46 Countries. *Educational Research, 36*(7), 369-387.

Alberta Education. (2011). *Western and Northern Canada Protocol (WNCP) for collaboration in education, Guiding Principles for WNCP Curriculum Framework Projects*. Retrieved from www.wncp.ca/media/49521/protocol.pdf.

Andrew, P., & Hatch, G. (2000). A comparison of Hungarian and English teachers' conceptions of mathematics and its teaching. *Educational Studies in Mathematics, 43*(1), 31-64.

Andrews, L., Higgins, A., Andrews, M. W., & Lalor, J. G. (2012). Classic grounded theory to analyse secondary data: Reality and reflections. *The Grounded Theory Review, 11*(1), 12-26.

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education, 52*(1), 154-168.

Asparouhov, T., & Muthén, B. (2009). Exploratory structural equation modeling. *Structural Equation Modeling, 16*, 397-438.

Attwel, G., & Hughes, J. (2010). Pedagogic Approaches to Using Technology for Learning - Literature Review. Retrieved from http://dera.ioe.ac.uk/2021/1/harnessing-technology-literature-reviewjanuary-111.pdf.

Au, Y. A., & Kauffman, R. J. (2008). The economics of mobile payments: Understanding stakeholder issues for an emerging financial technology application. *Electronic Commerce Research and Applications, 7*(2), 141-164.

Baldi, S., Jin, Y., Skemer, M., Green, P. J., & Herget, D. (2007). Highlights From PISA 2006: Performance of U.S. 15-Year-Old Students in Science and Mathematics Literacy in an International Context (NCES 2008-016). *National Center for Education Statistics.*

Ball, D. L., Simons, J., Wu, H. H., Simon, R., Whitehurst, G., & Yun, J. (2008). Chapter 5: Report of the task group on teachers and teacher education. *National Mathematics Advisory Panel, Reports of the task groups and subcommittees, 5-1*, 5-67.

Barrett, P. (2007). Structural equation modelling: adjudging model fit. *Personality and Individual Differences, 42*(5), 815-824.

Bauer, J., & Kenton, J. (2005). Toward technology integration in the schools: Why it isn't happening. *Journal of Technology and Teacher Education, 13*(4).

Beaton, A. E., Mullis, I. V. S., Martin, M. O., Gonzalez, E. J., Kelly, D. L., & Smith, T. A. (1996). Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMMS). Chesnut Hill, MA: Boston College.

Beatty, A., Paine, L. W., & Ramirez, F. O. (1999). *Next Steps for TIMSS: Directions for Secondary Analysis*. Washington, DC: National Academy Press.

Becker, H. J. (1991). When powerful tools meet conventional beliefs and institutional constraints. *The Computing Teacher, 18*(8), 6-9.

Beetham, H., McGill, L., & Liitlejohn, A. (2009). Thriving in the 21st century: Learning literacies for the digital age (LLiDA project): Executive Summary, Conclusions and recommendations.

Beetham, H., & Sharpe, R. (2007). *An introduction to rethinking pedagogy for digital age. in H.B.R. Sharpe (Ed.), Rethinking pedagogy for a digital Age: Designing and delivering e-learning*. London: Routledge.

Bhattacherjee, A. (2012). *Social Science Research: Principles, Methods and Practices*. Florida: University of Florida.

Birley, G., & Moreland, N. (1998). *The practical guide to academic research*. London: Kogan Page.

Blaikie, N. (1993). *Approaches to Social Enquiry, First edition*. Cambridge: Polity Press.

Bless, C., & Higson-Smith, C. (2000). *Fundamental of social reserach methods: An Africn perspective*. Cape Town: Juta.

Blignaut, A. S., Els, C. J., & Howie, S. (2010). Contextualizing South Africa's participation in the SITES 2006 module. *South African Journal of Education, 30*(4), 555-570.

Blumberg, B., Cooper, D. R., & Schindler, P. S. (2011). *Business Research Methods,* (Vol. 3rd ed). (European Edition); McGraw-Hill Education: New York, NY, USA.

Borg, I., & Groenen, P. (1997). *Modern Multidimensional Scaling, Theory and Applications*. New York: Springer-Verlag.

Borko , H., & Putnam, R. (1996). Learning to teach. In R. C. Calfee & D. C. Berliner (Eds.), Handbook of educational psychology (pp.673-708). New York: Macmillan.

Braak, J. V. (2001). Individual characteristics influencing teachers' class use of computers. *Journal of Educational Computing Research, 25*(2), 141-157.

Bracey, G. (1993). New pathways: Technology's empowering influence on teaching. *Electronic Learning, 12*(7), 8-9.

Brentari, E., Golia, S., & Manisera, M. (2006). Analysis ordinal data to measure customer satisfaction: a comparison between Rash Model and CaTPCA. Retrieved from http://mitsd06.unior.it/collegamenti/MTISD%202006/Abstract/03_brentari%20_1_.pdf.

Briggs, S. R., & Cheek, J. M. (1986). The role of factor analysis in the development and evaluation of personality scales. *Journal of Personality, 54*(1), 106-148.

Brown, G. T. L. (2004). Teachers' conceptions of assessment: Implications for policy and professional development. *Assessment in Education: Principles, Policy & Practice, 11*(3), 301-318.

Bryman, A., & Bell, E. (2007). *Business Reserach Methods, 2nd Edition*. Oxford: University Press.

Bull, G., & Hammond, T. (2008). The future of E-Learning in schools. In: Adelsberger, H. H., Kinshuk, Pawlowski, J. M., Sampson, D. (Eds.), Handbook on Information Technologies for Education and Training, 2nd Edition. Springer-Verlag Heidelberg. 345–361.

Bull, G., Hammond, T., & Ferster, B. (2008). Developing Web 2.0 tools for support of historical inquiry in social studies. *Computers in the Schools, 25*(3-4), 275-287.

Burt, C. (1948). Factor analysis and canonical correlations. *British Journal of Mathematical and Statistical Psychology, 1*(2), 95-106.

Calderhead, J. (1996). Teachers' beliefs and knowledge, in: D. C. Berliner & R. C. Calfee (Eds) Handbook of educational psychology (New York, Simon & Schuster Macmillan). 709-725.

Cattagni, A., & Westat, E. F. (2001). *Internet Access in US Public Schools and Classrooms-1994-2000*. US Department of Education. Office of Educational Research and Improvement.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Journal of Educational Technology & Society, 16*(2), 31-51.

Chen, L., Gillenson, M., & Sherrell, D. (2004). Consumer acceptance of virtual stores: a theoretical model and critical success factors for virtual stores. *ACM SIGMIS Database: the DATABASE for Advances in Information Systems, 35*(2), 8-31.

Cheng, H. G., & Phillips, M. R. (2014). Research methods in psychiatry: Secondary analysis of existing data: opportunities and implementation. *Shanghai Archives of Psychiatry, 26*(6), 371-375.

Cheung, W., Chang, M. K., & Lai, V. S. (2000). Prediction of Internet and World Wide Web usage at work: a test of an extended Triandis model. *Decision Support Systems, 30*(1), 83-100.

Clark, C., & Peterson, P. (1986). "Teachers' thought processes" In M. Wiltrock, ed. Handbook of Research on Teaching. 3rd Edition. New York: Macmillan 255-296.

Clark, C. M. (1988). Asking the right questions about teacher preparation. Contributions of research on teacher thinking. *Educational Researcher, 17*(2), 5-12.

Cohen, L., & Manion, L. (2007). *Research Methods in Education, Sixth Edition*. London: Routlege Falmer.

Collinson, V. (1996). *Staff development through inquiry: opening a Pandora's Box of teacher beliefs*. Paper presented at the at the annual meeting of the Association of Teacher Educators, St. Louis, MO: ERIC database (ED393842).

Coolidge, F. (2000). *A gentle introduction*. Thousand Oaks: sage Publications.

Cooney, T. J. (1985). A beginning teachers' view of problem solving. *Journal for Research in Mathematics Education, 16*(5), 324-336.

Cooper, D. R., & Schindler, P. S. (2008). *Business Research Methods*. (Ninth edition).TaTa McGraw Hill Education Private Limited. pp. 136-219.

Cormack, D. S. (1991). *The research process*. Oxford: Black Scientific.

Cox, S., & Graham, C. (2009). *An elaborated model of the TPACK framework*. Paper presented at the Society for Information Technology & Teacher Education International Conference, Chesapeake, VA: AACE.

Creswell, J. W. (1994). *Research Design: Qualitative and Quantitative Approaches*. Thousand Oaks, CA: Sage Publication, Inc.

Creswell, J. W. (1998). Qualitative inquiry and research design. Choosing among five traditions. Thousand Oaks, CA: Sage.

Croninger, R. G., & Douglas, K. M. (2005). Missing data and institutional research. *New Directions for Institutional Research, 2005*(127), 33-49.

Cross, D. I. (2009). Alignment, cohesion, and change: Examining mathematics teachers' belief structures and their influence on instructional practices. *Journal of Mathematics Teacher Education, 12*, 325–346. doi:10.1007/s10857-009-9120-5.

Crossley, M., & Jarvis, P. (2000). Introduction: Continuity, challege and change in comparative and international education. *Comparative Education, 36*(3), 261.

Crotty, M. (1998). *The foundations of social research:Meaning and perspectives in the research process*. London: Sage Publications Limited.

Curry, A. (2000). Canadian LIS education: Trends and issues 1. *Education for Information, 18*(4), 325-337.

Della Porta, D., & Keating, M. e. (2008). *Approaches and Methodologies in the Social Sciences. A Pluralist Perspective*. Cambridge: Cambridge University Press.

Denyer, D., & Tranfield, D. (2009). Producing a litertature review, in Buchanan and Bryman (2009), SAGE Handbook of Organizational Research Methods (Chapter 39), SAGE Publications Ltd, London, England.

Department of Basic Education. (2013). *Education Statistics in South Africa 2011*. Pretoria: Department of Basic Education.

Department of Basic Education. (2013). *Macro Indicator Report, Republic of South Africa*. Pretoria: Government printers.

Department of Education. (2001). *National Strategy for Mathematics, Science and Technology Education in General and Further Education and Training* Pretoria: Government Printer.

Department of Education. (2002). *Annual Report. Pretoria*. Retrieved from http://education.pwv.gov.za/Policies%20and20Reports/202_Reports.

Department of Education. (2003). *National Curriculum Statement Grade 10-12 (Mathematical Literacy)*. Pretoria: Government Printer.

Department of Education. (2004). *White Paper on e-Education. Transforming Learning and Teaching through Information and Communication Technologies (ICTs)* Pretoria: Government Printer.

Department of Education. (2006). *National Curriculum statement Grades 10-12 (general). Teacher Guide: Mathematical Literacy*. Pretoria: Department of Education.

DeVellis, R. F. (1991). *Scale Development: theory and application (Application Social Reserach Methods Series, Vol.26)*. Newbury Park: Sage Publications.

Drew, C. J., Hardman, M. L., & Hosp, J. L. (2007). *Designing and conducting research in education*. LA: Sage Publications.

Duffy, M. E. (1985). Designing nursing research: the qualitative-quantitative debate. *Journal of Advanced Nursing, 11*(3), 225-232.

Dwyer, D., Ringstaff, C., & Sandholtz, J. (1991). hanges in teachers' beliefs and practices in technology-rich classrooms. *Educational Leadership, 48*(8), 45-52.

Ellis, R. A., & Goodyear, P. (2010). *Students' experiences of e-learning in higher education: The ecology of sustainable innovation*. New York: Routledge.

Eriksson, P., & Kovalainen, A. (2008). *Qualitative methods in business research*. London: Sage Publications.

Ernest, P. (1991). *The philosophy of mathematics education*. London: Falmer Press.

Felbrich, A., Kaiser, G., & Schmotz, C. (2012). The cultural dimension of beliefs: an investigation of future primary teachers' epistemological beliefs concering the nature of mathematics in 15 countries *International Perspectives on Teacher Knowledge, Beliefs and Opportunities to Learn* (pp. 209-229): Springer.

Field, A. (2009). *Discovering Statistics using SPSS*. London: Sage Publications.

Field, A. (2014). *Discovering statistics using IBM SPSS Statistics* (4th ed.). California: Sage Publications Inc.

Foy, P., Arora, A., & Stanco, G. M. (2011). TIMSS 2011 User Guide for the International Database. Chestnut Hill, MA: TIMSS & PIRLS International Study Center,Lynch School of Education, Boston College.

Furinghetti, F., & Pehkonen, E. (2002). Rethinking Characterizations of Beliefs. *In G. C. Leder, E.Pehkonen & G. Törner (Eds.), Beliefs: A Hidden Variable in Mathematics Education? Dordrecht: Kluwer Academic Publishers*, 39-58.

Geisert, P., & Futrell, M. (2000). *Teachers, computers, and curriculum: Microcomputers in the classroom*. Boston, MA: Allyn and Bacon.

Gephart, R. (1999). *Paradigms and research methods*.

Ghauri, P., Grønhaug, K., & Kristianslund, I. (1995). *Research methods in business studies: A practical study*. New York: Prentice Hall.

Gibberd, J. (2007). South Africa’s School Infrastructure Performance Indicator System.

Gillen, J., & Barton, D. (2010). A Research Briefing Technology Enhanced Learning phase of the Teaching and Learning Research Programme at London Knowledge Lab. Retrieved from http://www.qca.org.uk/libraryAssets/media/12292_commun_now_and_in_the_future.pdf.

Gosper, M., & Ifenthaler, D. (2013). Curriculum Design for the Twenty-First Century. *In Curriculum Models for the 21st Century: Using Learning Technologies in Higher Education, 14*.

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education, 57*(3), 1953–1960. doi:10.1016/j.compedu.2011.04.010.

Greener, S. (2008). *Business Research Methods*: Ventus publishing ApS.

Greenmwald, R., Hedges, L. V., & Laine, R. D. (1996). The effect of school resources on student achievement. *Review of Educational Research, 66*(3), 361-396.

Grinyer, A. (2009). The ethics of secondary analysis and further use of qualitative data. *Social Research Update, Issue 56, University of Surrey*.

Grønmo, L. S., & Onstad, T. (2013). *The Significance of TIMSS and TIMSS Advanced: Mathematics Education in Norway, Slovenia and Sweden*. Retrieved from Blindern: Akademika Publishing.

Grønmo, L. S., Pavešić, B. J., Nyström, P., & Onstad, T. (2013). *The Significance of TIMSS and TIMSS Advanced. Mathematics Education in Norway, Slovenia and Sweden.*

Grossman, P. L. (1990). The making of a teacher: Teacher knowledge and teacher education. New York: Teachers College Press.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research*2*(163-194), 105-117.

Gulbahar, Y. (2007). Technology planning: A roadmap to successful technology integration in schools. *Computers & Education, 49*(4), 943-956. doi:10.1016/j.compedu.2005.12.002.

Gür, H., & Karamete, A. (2015). A short review of TPACK for Teacher Education. *Educational Research and Reviews, 10*(7), 777-789. doi:10.5897/ERR2014.1982.

Gustafsson, J. E. (2008). Effects of International Comparative Studies on Educational Quality on the Quality of Education Research. *European Educational Research Journal, 7*(1), 1-17. doi:dx.doi.org/10.2304/eerj.2008.7.1.1.

Haciomeroglu, E. S., Bu, L., Schoen, R. C., & Hohenwarter, M. (2011). Prospective teachers'experience in developing lessons with dynamic mathematics software. *International Journal for Technology in Mathematics Education, 18*(2), 71-82.

Haertel, E. H. (1997). Exploring and explaining u.s. TIMSS performance. Retrieved August 03, 2015 from http://www.enc.org.

Hair, J. J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate dta analysis (Sixth Editon)*. Upped Sadde, NJ: Pearson Prentice Hall.

Hammond, T. C., & Manfra, M. (2009). Giving, prompting, making: Aligning technology and pedagogy within TPACK for social studies instruction. *Contemporary Issues in Technology and Teacher Education, 9*(2), 160-185.

Handal, B. (2003). Teachers' Mathematical Beliefs: A Review. *The Mathematics Educator, 13*(2), 47-57.

Hannafin, R., & Savenye, W. (1993). Technology in the classroom: The teacher's new role and resistance to it. *Educational Technology, 33*(6), 26-31.

Hannafin, R. D., & Freeman, D. J. (1995). An exploratory study of teachers' views of knowledge acquisition. *Educafiond Technology, 35*(1), 29-56.

Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of Research on Technology in Education, 41*(4), 393-416.

Harris, P., & Sullivan, M. F. (2000). Using technology to create a new paradigm for a learner-centered educational experience. *Technos-Bloomington, 9*(2), 35-36.

Haydn, T., & Barton, R. (2007). Common needs and different agendas: how trainee teachers make progress in their ability to use ICT in subject teaching. Some lessons from UK. *Computers and Education, 49*, 1018-1036.

Heaton, J. (1998). Secondary analysis of qualitative data. *Social Research Update, Issue 22, University Press*.

Hedberg, J. G., & Stevenson, M. (2013). Breaking Away from Text, Time and Place. In Curriculum Models for the 21st Century: Using Learning Technologies in Higher Education (pp. 17-34): Springer.

Hencke, J., Rutkowski, L., Neuschmidt, O., & Gonzalez, E. J. (2009). Curriculum coverage and scale correlation on TIMSS 2003. *IERI monograph series: Issues and methodologies in large-scale assessments, 2*, 85-112.

Herther, N. K. (1997). Education over the Web: Distance learning and the information professional. *Online, 21*(5), 63-72.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: current knowledge gaps and recommendations for future research. *Education Technology Research Development, 55*, 223-252. doi:10.1007/s11423-006-9022-5.

Hoadley, U. (2012). What do we know about teaching and learning in South African primary schools? *Education as Change*, 16(2), 187-202.

Holt-Reynolds, D. (1992). Personal history-based beliefs as relevant prior knowledge in course work. *American Educational Research Journal, 29*(2), 325-349.

Honey, M., & Moeller, B. (1990). *Teacher's Beliefs and Technology Integration: Different Values, Different Understandings. [CTE Technical Report Issue No. 6] Education Developmnt Center, Inc*. Retrieved from www.edc.org/CCT/ccthome/reports/tr6.html.

Howey, K. R., & Grossman, P. L. (1989). A study in contrast: Sources of pedagogical content knowledge for secondary English. *Journal of Teacher Education, 40*(5), 24-31.

Howie, S. (2004). A national assessment in mathematics within an international comparative assessment. *Perspectives in Education, 22*(2), 149-162.

Howson, G. (1999). 11 The Value of Comparative Studies. *International comparison in mathematics education, 11*, 165-188.

Iding, M., Crosby, M. E., & Speitel, T. (2002). Teachers and technology: Beliefs and practices. *International Journal of Instructional Media, 29*(2), 153–171.

International Business Machine Corporation. (2012). *International Business Machine SPSS statistics (version 17.0)*. Somers, NY: Author.

Johnston, M. P. (2014). Secondary Data Analysis: A Method of which the Time Has Come. *Qualitative and Quantitative Methods in Libraries (QQML), 3*, 619 -626.

Jonassen, D., Peck, D., & Wilson, B. (Eds.). (1999). *Learning With Technology: A Constructivist Perspective.* . Upper Saddle River, NJ: Prentice Hall.

Jonassen, H. D. (2000). *Computers as mindtools for schools: Engaging critical thinking (2nd ed.)*. Upper Saddle River, NJ: Prentice-Hall.

Joncas, M. (2012). TIMSS 2011 target population sizes. In M. O. Martin & I. V. S. Mullis (Eds.) *Methods and Procedures in TIMSS and PIRLS 2011*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Joncas, M., & Foy, P. (2013). Sample design in TIMSS and PIRLS. In MO Martin & IVS Mullis (eds). Methods and procedures in TIMSS and PIRLS 2011. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Kagan, D. M. (1992). Implication of research on teacher belief. *Educational Psychologist, 27*(1), 65-90.

Kaiser, H. (1974). An index of factorial simplicity. *Psychometrika, 39*(1), 31-36.

Kaplan, A. (1973). *The conduct of inquiry: methodology for behavioral science.* Aylesbury: Intertext Books.

Kapur V & Sharma J 2013. Technology, education and emerging economies. Retrieved from: http://linc.mit.edu/linc2013/proceedings/Session1/Session1Kapur.pdf.

Kereluik, K., Mishra, P., & Koehler, M. J. (2011). On learning to subvert signs: Literacy, technology and the TPACK framework. *California Reader, 44*(2), 12-18.

Klien, P. (1996). Preservice Teachers' Beliefs about Learning and Knowledge. *Alberta Journal of Educational Research, 42*(4), 361-377.

Kline, R. B. (2012). *Assumptions in structural equation modeling. In R. Hoyle, Handbook of structural equation modeling*. NY: Guilford Press.

Koehler, M. J., & Mishra, P. (2005). Teachers learning technology by design. *Journal of Computing in Teacher Education, 21*(3), 94-102.

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*(2), 131-152.

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. In: AACTE committee on innovation and technology. Handbook of technological pedagogical content knowledge (TPCK) for educators New York: Routledge. 3-29.

Koehler, M. J., & Mishra, P. (2009). What is Technological Pedagogical Content Knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? . *Contemporary Issues in Technology and Teacher Education*(9(1)), 60-70.

Koehler, M. J., Mishra, P., Bouck, E. C., DeSchryver, M., & Kereluik, K. (2011). Deep-play: Developing TPACK for 21st century teachers. *International Journal of Learning Technology, 6*(2), 146-163.

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is Technological Pedagogical Content Knowledge (TPACK)? *Journal of Education, 193*(3), 13-19.

Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education, 49*(3), 740-762.

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. New Delhi: New Age International Publishers.

Krol, K., Veenman, S., & Voeten, M. (2001). *First-year Implementation Effects for Staff Development Program on Cooperative Learning paper presented at the European Conference for Research and Learning*.

Larkin, K., Jamieson-Proctor, R., & Finger, G. (2012). TPACK and pre-service teacher mathematics education: Defining signature pedagogy for mathematics education using ICT and based on the metaphor “mathematics is a language”. *Computers in the Schools, 29*(1-2), 207-226.

Lassibille, G., & Navarro, G. (2000). Organisation and Efficiency of Education Systems: some empirical findings. *Comparative Education, 36*(1), 7-19.

Lather, P. (1986). Research as praxis. *Harvard Educational Review, 53*(3), 257-277.

Law, N., & Chow, A. (2008). *Teacher characteristics, contextual factors and how these affect the pedagogical use of ICT. In N. Law, W.J. Pelgrum & T. Plomp (Eds.),Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study (Vol. 23, pp. 182-223)*.

Law, N., Pelgrum, W. J., & Plomp, T. (2008). *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study*.

Leach, M. (1990). Philosophical choice. *Journl of Education, 3, 3*, 16-18.

Lee, H., & Hollebrands, K. (2008). Preparing to teach mathematics with technology: An integrated approach to developing technological pedagogical content knowledge. *Contemporary Issues in Technology and Teacher Education., 8*(4), 326-341.

Leedy, P. D., & Ormrod, J. E. (2005). *Practical research:planning and design (Eighth Edition)*: Merrill Prentice Hall.

Lepik, M., & Pipere, A. (2011). Baltic-Nordic comparative study on mathematicsteachers’ beliefs: designing research instrument to describe the beliefs and practices of mathematics teachers. *Acta Paedagogica Vilnensia, 27*, 115-123.

LeTendre, G., Baker, D., Akiba, M., Goesling, B., & Wiseman, A. (2001). Teachers’ work: Institutional isomorphism and cultural variation in the US, Germany, and Japan. *Educational Researcher, 30*(6), 3-15.

Light, P. C. (1998). *Sustaining innovation*. San Francisco: Jossey-Bass.

Liljedahl, P., Rolka, K., & Rosken, B. (2007). Affecting affect: The reduction of preservice teachers' beliefs about mathematics and mathematics learning and teaching. In W.G. Martin, M.E. Structhens & P.C. Elliott (Eds.), The learning of mathematics (pp. 319-330). Danver: National Council of Teachers of Mathematics.

Lingting, M. (2007). *Nonparametric Inferences in Nonlinear Principal Component Analysis: Exploraion and Beyond*: Leiden University.

Lorenzo-Seva, U., & ten Berge, J. M. F. (2006). Tucker's congruence coefficient as a meaningful index of factor similarity. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences, 2*(2), 57-64.

Lynn, R., & Mikk, J. (2007). National differences in intelligence and educational attainment. *Intelligence, 35*, 115-121. doi:10.1016/j.intell.2006.06.001.

Mansour, N. (2009). Science teachers' beliefs and practices: Issues, implications and research agenda. *International Journal of Environmental & Science Education, 4*(1), 25-48.

Marks, G. N. (2008). Accounting for the Gender Gap in Reading and Mathematics: Evidence from 31 Countries. *Oxford Review of Education, 34*(1), 89-109.

Martin, M. O., Mullis, I. V. S., Foy, P., & Stanco, G. M. (2012). TIMSS 2011 International Results in Mathematics. Chestnut Hill, MA: Boston College.

McGregor, S. L., & Murnane, J. A. (2010). Paradigm, methodology and method: Intellectual integrity in consumer scholarship. *International Journal of Computer Studies, 34*(4), 419-427.

McLeod, D. B. (1992). *Research on affect in mathematics education: a reconceptualization, in D.A.Grouws (Ed.) Handbook of research on mathematics learning and teaching* New York: MacMillan.

Mertens, D. M. (1998). *Research methods in education and psychology: Integrating diversity with quantitative and qualitative approaches*. Thousand Oaks, CA: Sage.

Meulman, J. J., Van der Kooij, A. J., & Heiser, W. J. (2004). *Principal components analysis with nonlinear optimal scaling transformations for ordinal and nominal data. In Handbook of Quantitative Methodology for the Social Sciences (Ed. D. Kaplan)*.

Meulmann, J. J., & Heiser, W. J. (2005). *Categorical Principal Component Analysis (CATPCA)*. USA: SPSS Inc.

Ministry of Education. (2003). *Standards for Senior High School Mathematics Curriculum* Beijing: People's Education Press.

Misco, T. (2007). The frustrations of reader generalizability and grounded theory: alternative considerations for transferability. *Journal of Research Practice, 3*, 1-11.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A new Framework for Teacher Knowledge. *Teachers' College Record, 108*(6), 1017-1054.

Molinero, C., Portillo, F., & Hayes, R. (2007). *Analysis the success of a MBA programme*. Kent Business School.

Muijs, D. (2004). *Doing Quantitative Research in Education with SPSS*. London: Sage Publications.

Muir-Herzig, R. G. (2004). Technology and its impact in the classroom. Computers and Education,. *Computers and Education, 42*, 111-131.

Mullis, I. V. S., Martin, M., Beaton, A. E., Gonzalez, E. J., Kelly, D. L., & Smith, T. A. (1996). Mathematics Achievement in the Middle School years: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA, USA.

Mullis, I. V. S., Martin, M., Beaton, A. E., Gonzalez, E. J., Kelly, D. L., & Smith, T. A. (1997). Mathematics Achievement in the Primary School years: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA, USA: Boston College.

Mullis, I. V. S., & Martin, M. O. (2006). TIMSS in Perspective: Lesson Learned from IEA's Four Decades of International Mathematics Assessment. Boston College: Lynch School of Education.

Mullis, I. V. S., & Martin, M. O. (2011). Trends in Mathematics and Science Study (TIMSS). Item writing guidelines. Chestnut Hill, MA, USA: Boston College.

Mullis, I. V. S., Martin, M. O., & Foy, P. (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eight Grades*. Chestnut Hill, MA: Boston College.

Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 International Results in Mathematics*. Chestnut Hill, MA, USA: Boston College.

Mullis, I. V. S., Martin, M. O., Foy, P., Olson, J., Preuschoff, C., Erberber, E., . . . Galia, J. (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eight Grades*. Retrieved from Lynch School of Education, Boston College.

Mullis, I. V. S., Martin, M. O., Goh, S., & Cotter, K. E. (2016). TIMSS 2015 Encyclopedia: Education Policy and Curriculum in Mathematics and Science. Retrieved from Boston College, TIMSS & PIRLS International Study Center.

Mullis, I. V. S., Martin, M. O., Gonzales, E. J., Gregory, K. D., Smith, T. A., Chrostowski, S. J., . . . O'Connor, K. M. (2000). TIMSS 1999 international mathematics report: Findings from IEA's repeat of the Third International Mathematics and Science Study at the eighth grade. Retrieved September 2, 2015 from http://isc.bc.edu/timss1999i /math_achievement_report.html.

Mullis, I. V. S., Martin, M. O., Gonzalez, E. J., & Chrostowski, S. J. (2004). TIMSS 2003 International Mathematics. Report: Findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades. Boston College: TIMSS & PIRLS International Study Center, Lynch School of Education.

Mullis, I. V. S., Martin, M. O., Minnich, C. A., Stanco, G. M., Arora, A., Centurino, V. A. S., & Castle, C. E. E. (2012). TIMSS 2011 Encyclopedia: Education policy and curriculum in mathematics and science (Vol. 1-2). Chestnut Hill, MA: Boston College.

Murphy, S. (2010). The Pull of PISA: Uncertainty, Influence, and Ignorance. *Interamerican Journal of Education for Democracy, 3*(1), 28-44.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Nelson, D. (2002). Using TIMSS to Inform Policy and Practice at the Local Level. CPRE Policy Briefs. Retrieved from http://repository.upenn.edu/cpre_policybriefs/24.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*(4), 317-328.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509-523.

Niess, M. L. (2006). Guest Editorial: Preparing teachers to teach mathematics with technology. *Contemporary Issues in Technology and Teacher Education, 6*(2), 195-203.

Niess, M. L., Ronau, R. N., Shafer, K. G., Driskell, S. O., Harper, S., Johnston, C., . . . Kersaint, G. (2009). Mathematics teacher TPACK standards and development model. *Contemporary Issues in Technology and Teacher Education, 9*(1), 4-24.

Niess, M. L., Sadri, P., & Lee, K. (2007). *Dynamic spreadsheets as learning technology tools: Developing teachers' technology pedagogical content knowledge (TPCK).* Paper presented at the Paper presented at the meeting of the American Educational Research Association Annual Conference, Chicago, IL.

O'Connell, B. (2009). *The Dinaledi Schools Project. Report from a strategic engagement between the national Department of Education and business on increasing support for mathematics and science education in schools*. South Africa.

Oblinger, D., & Oblinger, J. (2005). *Is it age or IT: First steps toward understanding the net generation. In D. Oblinger & J. Oblinger (Eds.), Educating the net generation*. Boulder, CO: Educause.

Olech, C. (1997). *The relationship between teachers' pedagogical beliefs and the level of instructional cornputer use. Doctoral dissertation, University of Central Flonda.*

Ondrus, J., & Pigneur, Y. (2006). Towards a holistic analysis of mobile payments: A multiple perspectives approach. *Electronic Commerce Research and Applications, 5*(3), 246-257.

Özgün-Koca, S., Meagher, M., & Edwards, M. T. (2010). Preservice teachers' emerging TPACK in a technology-rich methods class. *Mathematics Educator, 19*(2), 10-20.

Pajares, M. F. (1992). Teachers' Beliefs and Educational Research: Cleaning Up a Messy Construct. *Review of Educational Research, 62*(3), 307-332.

Pelgrum, W. J. (1992). International research on computers in education. *Prospects, 22*, 341-349.

Pepin, B. (1999). Epistemologies, beliefs and conceptions of mathematics teaching and learning: The theory, and what is manifested in mathematics teacher's work in England, France and Germany. *TNTEE Publications, 2*(1), 127-146.

Pierson, M., & Borthwick, A. (2010). Framing the assessment of educational technology professional development in a culture of learning. *Journal of Computing in Teacher Education, 26*(4), 126-131.

Pierson, M. E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education, 33*(4), 413-430.

Plomp, T. J. (1998). The potential of international comparative studies to monitor the quality of education. *Prospects, 28*(1), 45-59.

Polit, D., F. , & Beck, C., T. . (2010). Generalization in quantitative and qualitative research: Myths and strategies. *International Journal of Nursing Studies, 47* (2010), 1451–1458.

Polly, D., Mims, C., Shepherd, C. E., & Inan, F. (2010). Evidence of impact: Transforming teacher education with preparing tomorrow's teachers to teach with technology (PT3) grants. Teaching and Teacher Education. *Teaching and Teacher Education, 26*(4), 863-870.

Postlethwaite, N. (1967). School organization and student achievement: A study based on achievement in mathematics in twelve countries.

Postlethwaite, T. N. (1988). The encyclopedia of comparative education and national systems of education. Oxford: Pergamon Press.

Powell, R. R. (1992). he influence of prior experiences on pedagogical constructs of traditional and nontraditional preservice teachers. *Teaching and Teacher Education, 8*(3), 225-238.

Prawat, R. S. (1992). Teachers' beliefs about teaching and learning: A constructivist perspective. *American Journal of Education, 100*(3), 354-395.

Qin, H. F., & Li, Z. H. (2013). Research on the Methods of Big Data Analysis. *Information Technology*, 1-7. doi:10.3923/itj.2013.

Rahimi, S. R., Beer, C. D., & Sewchurran, K. (2012). *International Journal of Information and Education Technology, 2*(6). doi:10.7763/IJIET.2012.V2.217.

Reddy, B. V. (2006). *Mathematics and science achievement at South African schools in TIMSS 2003*. Cape Town, South Africa: HSRC Press.

Rice, J. K. (2003). *Teacher quality: Understanding the effectiveness of teacher attributes*. Washington DC: Economic Policy Institute.

Robert, L. M., & Brewer, J. D. (2003). *The A- Z of Social Research: A Dictionary of Key Social Science Research Concepts*. London · Thousand Oaks · New Delhi: SAGE Publications.

Robin, B. R. (2008). Digital Storytelling: A Powerful Technology Tool for the 21st Century Classroom. *Theory Into Practice, 47*, 220–228. doi:10.1080/00405840802153916.

Robinson, J., E. , & Norris, N., F., J. . (2001). Generalisation: the linchpin of evidence-based practice? . *Educational Action Research, 9*(2), 303-310. doi:10.1080/09650790100200155.

Robitaille, D. F. (1997). *National context for mathematics and science education: an encyclopaedia of the educational systems participating in TIMSS*. Vancouver, BC: Pacific Education Press.

Robitaille, D. F., & Beaton, A. E. (2002). *Secondary analysis of the TIMSS data.* Dordrecht: Kluwer Academic Publishers.

Robitaille, D. F., & Garden, A. (1989). The IEA study of mathematics II: Context and outcomes of school mathematics. Oxford: Pergamon Press.

Rogers, E. M. (1995). *Diffusion of Innovation* (Vol. 4th ed). New York: Free Press.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York, NY: Kindle Edition.

Rowland T & Ruthven K (eds.) 2011. Introduction: Mathematical knowledge in teaching. *In Mathematical knowledge in teaching (pp.1-5)*. New York: Springer.

Säljö, R. (2010). Digital tools and challenges to institutional traditions of learning: technologies, social memory and the performative nature of learning. *Journal of Computer Assisted Learning, 26*(1), 53-64. doi:10.1111/j.1365-2729.2009.00341.x

Salkind, N. E. (2010). *Encyclopeadia of Measurement and Statistics*. Thousand Oaks (CA): Sage.

Saunders, M., Lewis, P., & Thornhill, A. (2007). *Research Methods for Business Students (Fourth Edition)*. London: Pearson.

Saunders, M., Lewis, P., & Thornhill, A. (2007). *Research Methods for Business Students. Fourth edition.* . London: Pearson Education.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students. Fifth Edition*. London: Pearson Education.

Schlöglmann, W., & Kepler, J. (2006). Beliefs concerning mathematics held by adult students and their teachers. In K.Hoskonen & M. S. Hannula (Eds.), Current state of research on mathematical beliefs XII. Proceedings of the MAVI-7 workshop (Research report 288) (pp. 97-112). Department of Applied Science of Education, University of Helsinki.

Schoenfeld, A. H. (1985). *Mathematical problem solving*. Orlando (FL): Academic Press.

Schoenfeld, A. H. (1998). Toward a theory of teaching-in-context. *Issues in Education, 4*(1), 1-94.

Schwille, J., Porter, A., Floden, R., Freeman, D., Knapp, L., Kuhs, T., & Schmidt, W. (1983). *Teachers as policy brokers in the content of elementary school mathematics. In L. Shulman and G. Sykes (Eds.), Handbook of teaching and policy (pp. 370-391)*. New York: Longman.

Shelton, C. A. (2007). The size and composition of government expenditure. *Journal of Public Economics, 91*, 2230 - 2260.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-23.

Shultz, K.S.; Hoffman, C.C.; & Reiter-Palmon, R., *Using Archival Data for I-O Research: Advantages, Pitfalls, Sources, and Examples* (2005). The Industrial-Organizational Psychology 42(3). R, 31. Retrieved from https://digitalcommons.unomaha.edu/psychfacpub/5.

Sime D & Priestley M 2005. Student teachers' first reflections on information and communications technology and classroom learning: implications for initial teacher education. *Journal of Computer-Assisted Learning*, 21(2):130-142. doi: 10.1111/j.1365-2729.2005.00120.x.

Skrondal, A., & Rabe-Hesketh, S. (2004). *Interdisciplinary Statistics. Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models*. Chapman and Hall/CRC. New York.

Smith, A. K., Ayanian, J. Z., Covinsky, K. E., Landon, B. E., McCarthy, E. P., Wee, C. C., & Steinman, M. A. (2011). Conducting high-value secondary dataset analysis: an introductory guide and resources. *Journal of general internal medicine, 28*(8), 920-929.

Smith, E. (2008). *Using secondary data in education and social research. (2nd edition)*. McGraw-Hill Education: Open University Press.

Smith, E. (2008). *Using Secondary Data in Educational and Social Research*. Buckingham: Open University Press.

Speer, N. (2005). Issues of methods and theory in the study of mathematics teachers' professed and attributed beliefs. *Educational Studies in Mathematics, 58*(3), 361-391.

Stigler, J., Gallimore, R., & Heibert, J. (2000). Using video surveys to compare classrooms and teaching across cultures: Examples and lessons from the TIMSS video studies. *Educational Psychologist, 35*(2), 87-100.

Stipek, D. J., Givvin, K. B., Salmon, J. M., & MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching and Teacher Education, 17*, 213-226.

Surry, D. W., & Farquhar, J. D. (1997). Diffusion theory and instructional technology. *Journal of Instructional Science and Technology, 2*(1), 24-36.

Sutherland, R., Armstrong, V., Barnes, S., Brawn, R., Breeze, N., & Gall, M. (2004). Transforming teaching and learning: Embedding ICT into everyday classroom practices. *Journal of Computer Assisted Learning, 20*, 413–425.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using Multivariate Statistics* (5th ed.). New York: Allyn and Bacon.

Taylor, P. (1990). *The infience of teachers' beliefs on constnrctivist teaching practices*. Paper presented at the Paper presented at the Annual Meeting of the American Research Association, (Boston, MA. Apnl 17-20).

Ten Berge, J. M. F. (1977). Orthogonal Procrustes rotation for two or more matrices. *Psychometrika, 42*, 267-276.

TerreBlanche, M., & Durrheim, K. (1999). *Research in practice: applied methods for the social sciences*. Cape Town: University of Cape Town Press.

Theunissen, N. C. M., Meulman, J. J., den-Ouden, A. L., Koopman, H. M., Verrips, G. H., Verloove-Vanhorick, S. P., & Wit, J. M. (2003). Changes can be studied when the measurement instrument is different at different time points. *Health Services and Outcomes Research Methodology, 4*(2), 109-126.

Thompson, A. G. (1992). *Teachers' Beliefs and Conceptions: A Synthesis of the Research. In D.A. Grouws (Ed.), Handbook of Research on Mathematics Learning and Teaching.* . New York: Macmillan.

Toth, E. (2009). "Virtual Inquiry" in the science classroom: What is the role of technological pedagogial content knowledge? *International Journal of Information & Communication Technology Education, 5*(4), 78-87. doi:doi:10.4018/jicte.2009041008.

Triola, M. F. (2008). *Elementary statistics using the Ti-84/84 Plus Calculator* (2nd ed.). USA: Addison Wesley.

Trucano M, Iglesias C.J., & Hawkins R. 2012. Ten trends in technology use in education in developing countries that you may not have heard about. Retrieved from http://blogs.worldbank.org/edutech/some-more-trends. Accessed 30 October 2018.

Trzesniewski, K. M., Brent, D., & Lucas, E. (2010). *Secondary Data analysis: An Introduction for Psychologists*: American Psychological Association.

Tucker, L. R. (1951). *A method for synthesis of factor analysis studies (Personnel Research Section Report No.984)*. Retrieved from Washington, DC.

Turner, R., & Adams, R. J. (2007). The programme for international student assessment: An overview. *Journal of Applied Measurement, 8*(3), 237-248.

Twining, P. (2002). Conceptualising computer use in education: introducing the Computer Practice Framework (CPF). *British Educational Research Journal, 28*(1), 95-110.

Twining, P., Broadie, R., Cook, D., Ford, K., Morris, D., Twiner, A., & Underwood, J. (2006). *Educational change and ICT: an exploration of priorities 2 and 3 of the DfES e-strategy in schools and colleges: the current landscape and implementation issues*.

Van Braak, J., & Tearle, P. (2007). The computer attributes for learning scale (CALS) among university students: Scale development and relationship with actual computer use for learning. *Computers in Human Behavior, 23*(6), 2966-2982.

Van der Berg, S. (2007). Apartheid's Enduring Legacy: Inequalities in Education *Journal of African Economies, 16*(5), 849-880.

Vandecandelaere, M., Speybroeck, S., Vanlaar, G., De Fraine, B., & Van Damme, J. (2012). Learning environment and students' mathematics attitude. *Studies in Educational Evaluation, 38*(3-4), 107-120.

Vartanian, T. P. (2010). *Secondary Data Analysis. Pocket Guides to Social Research Methods*. USA: Oxford University Press.

Venkat, H., & Naidoo, D. (2012). Analyzing coherence for conceptual learning in a Grade 2 numeracy lesson. *Education as Change*, 16(1), 21–33.

Voogt, J., & Knezek, G. (2008). *International handbook of information technology in primary and secondary education* (Vol. 20). New York: Springer Science and Business Media, LLC.

Wand, Y., & Weber, R. (1993). On the ontological expressiveness of information systems analysis and design grammars. *Journal of Information Systems, 3*(4), 217-237.

Watanabe, T. (2001). Content and organization of teacher's manuals: An analysis of Japanese elementary mathematics teacher's manuals. *School Science and Mathematics, 101*(4), 194-205.

Watson, G. (2006). Technology Professional development: Long-term effects on teacher selfefficacy. *Journal of Technology and Teacher Education, 14*(1), 151-166.

Weller, M. (2002). *Delivering Learning on the Net: the why, what and how online education*. Routledge Falmer, Taylor and Francis Group: London and New York.

Wenger-Trayner, E., & Wenger-Trayner, B. (2015). Communities of practice: A brief introduction. Retrieved from http://wenger-trayner.com/introduction-to-communities-of-practice.

Werkman, R. A., Boonstra, J. J., & Van der Kloot, W. (2005). Changing organisations: Understanding complexity, not denying it. Paper presented at the Academy of management Annual Meeting. Retrieved from http://www.jaapboonstra/publicaties/engelstalig/changing%20organizations%20%20understanding%20complexity,pdf.

White, A. L., Way, J., Perry, B., & Southwell, B. (2005). Mathematical attitudes, beliefs and achievement in primary pre-service mathematics teacher education. *Mathematics Teacher Education and Development, 7*, 33-52.

White, M. (1987). *The Japanese educational challenge: A commitment to children*. New Yok: The Free Press.

Winfield, I. (1990). Organizations and information technology: Systems, power and job creation. Theoretical empiricism. Oxford: Alfred Waller Ltd.

Woods, D. (1996). Teacher Cognition in Language Teaching: Beliefi, decision-making and classroom practice. Cambridge: Cambridge University Press.

Wu, M. (2010). Measurement, sampling, and equating errors in large-scale assessments. *Educational Measurement: Issues and Practice,, 29*(4), 15-27. doi:10.1111/j.1745-3992.2010.00190.x.

Yigit, M. (2014). A Review of the Literature: How Pre-Service Mathematics Teachers Develop Their Technological, Pedagogical, and Content Knowledge. *International Journal on Education in Mathematics, Science and Technology, 2*(1), 26-35.

Yılmaz, H., & Şahin, S. (2011). Pre-Service Teachers' Epistemological Beliefs and Conceptions of Teaching. *Australian Journal of Teacher Education, 36*(1), 73-88.

Yin, R. K. (2011). *Qualitative Research from Start to Finish*. New York: The Guilford Press.

Zikmund, W. G. (2003). *Business Research Methods (Seventh Edition)*. Ohio: Thomson, South-Western.

ANNEXURES

8.1 Annexure A: List of countries, population and sampled schools

	Country	Alpha code	Population size	Sample size	Number of	
			Schools	Schools	Teachers	Learners
01	Australia	AUSM	2 420	277	524	7 556
02	Alberta Canada	CABM	652	145	211	4799
03	Armenia	ARMM	1 151	153	241	5 846
04	Alabama, US	UALM	506	55	No data	2 113
05	Abu Dhabi, UAE	AADM	233	166	186	4 373
06	Bahrain	BHRM	97	95	131	4 640
07	Botswana	BWAM	218	150	144	5 400
08	California, US	UCAM	2 709	82	No data	2 614
09	Chile	CHLM	5 351	193	186	5 835
10	Chinese Taipei	TWNM	915	150	162	5 042
11	Colorado, US	UCOM	492	53	No data	2 167
12	Connecticut, US	UCTM	279	62	No data	2 099
13	Dubai, UAE	ADUM	143	130	201	5 571
14	England	ENGM	3 742	118	195	3 842
15	Finland	FINM	715	145	257	4 266
16	Florida, US	UFLM	1 124	60	No data	1 712
17	Ghana	GHAM	9 166	161	166	7 323
18	Georgia	GEOM	1 914	172	201	4 563
19	Honduras	HNDM	1 896	155	138	4 418
20	Hungary	HUNM	2 865	146	272	5 178
21	Hong Kong SAR	HKGM	447	117	145	4 014
22	Iran, Islamic Rep	IRNM	27 463	238	238	6 029
23	Israel	ISRM	864	151	443	4 699
24	Italy	ITAM	5 935	197	195	3 979
25	Indiana, US	UINM	474	56	No data	2 260
26	Indonesia	IDNM	36 234	153	168	5 795
27	Jordan	JORM	2 065	230	250	7 694

	Country	Alpha code	Population	Sample	Number of	
			Schools	Schools	Teachers	Learners
28	Japan	JPNM	10 629	138	179	4 414
29	Kazakhstan	KAZM	5 977	147	203	4 390
30	Korea, Republic of	KOR	2 926	150	356	5 166
31	Lithuania	LTUM	846	141	261	4 747
32	Lebanon	LBNM	1 617	147	169	3 974
33	Malaysia	MYSM	1 892	180	178	5 733
34	Massachusetts	UMA	479	56	No data	2 075
35	Minnesota, US	UMNM	682	55	No data	500
35	Macedonia, Rep. of	MKDM	326	150	167	4 062
37	Morocco	MARM	2 214	279	266	8 986
38	North Carolina, US	UNCM	700	59	No data	2 103
39	Norway	NORM	1 162	134	171	3 862
40	New Zealand	NZLM	409	158	335	5 336
41	Ontario Canada	COTM	2 940	143	219	4 753
42	Oman	OMNM	678	323	350	9 542
43	Palestinian	PSEM	1 298	201	242	7 812
44	Quebec Canada	CQUM	598	189	250	6 149
45	Qatar	QATM	113	109	192	4 422
46	Romania	ROMM	6 325	147	246	5 523
47	Russian Federation	RUSM	37 000	210	237	4 893
48	Saudi Arabia	SAU	6 395	153	162	4 344
49	Singapore	SQPM	165	165	328	5 927
50	Slovenia	SVNM	449	186	486	4 415
51	South Africa	ZAFM	9 504	285	298	11 969
52	Sweden	SWEM	1 519	153	326	5 573
52	Syrian Arab Republic	SYRM	4 909	148	139	4 413
53	Thailand	THAM	10 210	172	172	6 124
55	Tunisia	TUNM	1 018	207	204	5 128
56	Turkey	TURM	17 261	239	239	6 928
57	United Arab Emirates	AREM	596	458	559	14 089
58	Ukraine	UKRM	15 522	148	159	3 378
59	United States	USAM	46 312	501	442	10 477
Total			**302 741**	**9 741**	**12 189**	**305 034**

8.2 Annexure B: Countries with GDP values close to South Africa

Annexure B:1 – Countries with GDP values close to South Africa

#	Names of countries	Code	2011 GDP per capita values (Billion US Dollars	Government expenditure on education (% of GDP)
1	Saudi Arabia	SAU	670.00	6
2	Iran, Islamic Rep	IRN	592.00	5
3	Sweden	SWE	563.10	7
4	Norway	NOR	498.20	7
5	South Africa	ZAF	416.60	5
6	Thailand	THA	370.60	5
7	United Arab Emirates	ARE	348.50	1
8	Malaysia	MYS	298.00	4
9	Singapore	SGP	275.40	3
10	Finland	FIN	273.70	6
11	Israel	ISR	261.80	6
12	Chile	CHL	250.80	4

Annexure B:1 – Countries with GDP values close to South Africa used in this study

#	Countries	Code	2011 GDP values	Number of	
			Billion US dollars	Teachers	Learners
1	Saudi Arabia	SAU	670.00	162	6 024
2	Iran, Islamic Rep	IRN	592.00	238	6 029
3	Sweden	SWE	563.10	326	5 573
4	Norway	NOR	498.20	171	3 862
5	South Africa	ZAF	416.60	298	11 969
6	Thailand	THA	370.60	172	6 124
7	United Arab Emirates	ARE	348.50	559	14 089
8	Malaysia	MYS	298.00	178	5 733
9	Singapore	SGP	275.40	328	5 927
Total				**2432**	**65 330**

8.1 Annexure C: Government expenditure on education

#	Countries Names and Code	Government expenditure on education (% of GDP)	Number of	
			Teachers	Learners
1	Norway (NOR)	7	171	3 862
2	Sweden (SWE)	7	326	5 573
3	Saudi Arabia (SAU)	6	162	6 024
4	South Africa (ZAF)	5	298	11 969
5	Thailand (THA)	4	172	6 124
6	Singapore (SGP)	3	328	5 927
6	United Arab Emirates (UAE)	1	559	14 089
Total			**2016**	**53 568**

8.2 Annexure D: Computer activities

With regard to computer activities, teachers were asked to indicate "How much they agree with the following statements about using computers as part of their classroom instruction?"

	TIMSS 2011 variables description - computer activities	File name
a)	I feel comfortable using computers in my teaching	BTM9A
b)	When I have technical problems, I have ready access to computer support staff in my schools	BTM9B
c)	I receive adequate support for integrating computers in my teaching activities	BTM9C
Total number of sub-questions		3

Teachers reported how frequently they used computer activities during mathematics lessons:

1) Agree a lot
2) Agree a little
3) Disagree a little
4) Disagree a lot

With regard to computer activities, teachers were asked to indicate "How often do you have learners do the following computer activities during mathematics lessons?"

	TIMSS 2011 variables description - computer activities	File name
a)	Explore mathematics principles and concepts	BTM22CA
b)	Practise skills and procedures	BTM22CB
c)	Look up ideas and information	BTM22CC
d)	Process and analyse data	BTM22CD
Total number of sub-questions		4

Teachers reported how frequently they used computer activities during mathematics lessons:

1) Every or almost every lesson
2) Once or twice a week
3) Once or twice a month
4) Never or almost never

8.3 Annexure E: Teaching strategies

The effects of several computer activities, teaching mathematics to the TIMSS class and mathematics content coverage will be examined in this study (four questions will be covered). The following questions will be extracted from the teachers' questionnaire:

Considering question 19, teachers were asked the following question: "*In teaching mathematics to this class, how often do you usually ask learners to do the following?*" to report on the use of the following instructional and learning strategies:

	TIMSS 2011 variables	**Question 19: Teaching mathematics to the TIMSS class**
	Description - Lesson activities	**File name**
a)	Listen to me explain how to solve problems	BTBM19A
b)	Memorise rules, procedures, and facts	BTBM19B
c)	Work problems (individually or with peers) with my guidance	BTBM19C
d)	Work problems together in whole class with direct guidance from me	BTBM19D
e)	Work problems (individually or with peers) while I am occupied by other tasks	BTBM19E
f)	Apply facts, concepts, and procedure to solve routine problems	BTBM19F
g)	Explain correct answers	BTBM19G
h)	Relate what they are learning in mathematics to their daily lives	BTBM19H
i)	Decide on their own procedure for solving complex problems	BTBM19I
j)	Work on problems for which there is no obvious method of solution	BTBM19J
k)	Take a written test or quiz	BTBM19K

For these items teachers indicated the following frequency of each lesson activity:

1) Every or almost every lesson
2) About half the lesson
3) Some lessons
4) Never

8.4 Annexure F: Content Coverage

With respect to teachers' content coverage in mathematics, teachers' response to four specific content coverage topics will be examined: *"How well prepared do you feel are able to teach the following mathematics topics?"*

A. Number		
TIMSS 2011 variables description		**File name**
a)	Computing, estimating or approximating with whole numbers	BTBM30AA
b)	Concepts of fractions and computing with fractions	BTBM30AB
c)	Concepts of decimals and computing with decimals	BTBM30AC
d)	Representing, comparing, ordering and computing with integers	BTBM30AD
e)	Problem solving involving percent and proportions	BTBM30AE
Total number of sub-questions		5

B. Algebra		
TIMSS 2011 variables description		**File name**
a)	Numeric, algebra and geometric patterns (extensions, missing terms, generalisations of patterns	BTBM30BA
b)	Simplifying and evaluating algebraic expressions	BTBM30BB
c)	Simple linear equations and inequalities	BTBM30BC
d)	Simultaneous (two variables) equations	BTBM30BD
e)	Representation of functions as ordered pairs, tables, graphs, words or equations	BTBM30BE
Total number of sub-questions		5

C. Geometry		
TIMSS 2011 variables description		**File name**
a)	Geometric properties of angles and geometric shapes (triangles, quadrilaterals, and other common polygons)	BTBM30CA
b)	Congruent figures and similar triangles	BTBM30CB
c)	Relationship between three-dimensional shapes and their two-dimensional representations	BTBM30CC
d)	Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	BTBM30CD
e)	Points on the Cartesian plane	BTBM30CE
f)	Translation, reflection, and rotation	BTBM30CF
Total number of sub-questions		6

D. Data and change		
TIMSS 2011 variables description		**File name**
a)	Reading and displaying data using tables, pictographs, bar graphs, pie graphs and line graphs	BTBM30DA
b)	Interpreting data sets (e.g. draw conclusions, make predictions, and estimate values between and beyond given data points)	BTBM30DB
c)	Judging, predicting, and determining the choices of possible outcomes	BTBM30DC
Total number of sub-questions		3
Total number of questions (A+B+C+D) =		19

For each of these items teachers reported their level of preparedness:

1) Not applicable
2) Very well prepared
3) Somewhat prepared
4) Not well prepared

8.5 Annexure G: Gender categories

G.1 : Distribution of learners according to their teachers gender categories

Names of countries	Gender	N of cases	Sum of MATWGT	Sum of MATWGT (s.e.)	Percent	Percent (s.e.)
Norway	Female	1 688	24 199	2207.15	39.98	3.63
	Male	2 190	36 324	2389.68	60.02	3.63
Saudi Arabia	Female	2 152	169 058	6245.07	48.23	1.33
	Male	2 125	181 470	6133.23	51.77	1.33
Singapore	Female	3 568	30 100	1355.15	60.33	2.71
	Male	2 324	19 790	1354.09	39.67	2.71
South Africa	Female	4 921	346 113	36665.21	42.19	3.80
	Male	6 191	515 304	35830.42	57.81	3.80
Sweden	Female	2 590	43 775	3158.76	54.65	3.44
	Male	2 165	36 320	3028.09	45.35	3.44
Thailand	Female	3 957	554 559	35138.87	65.47	3.98
	Male	2 167	292 473	34622.41	34.53	3.98
United Arab Emirates	Female	7 924	26 351	1124.39	58.26	1.83
	Male	5 518	18 876	817.66	41.74	1.83
Total Average	Female				52.73	1.18
	Male				47.27	1.18

8.6 Annexure H: Mathematics qualifications

I.1: Distribution of learners according to their teachers' qualifications

Mathematics as a major area of study

Government expenditure on education	Names of countries	Yes		No		Total	
		N of cases	%	N of cases	%	N of cases	%
Higher	Saudi Arabia	2 531	60.98	1 695	39.02	4 226	100
	Sweden	2 821	60.63	1 891	39.37	4 712	100
	Norway	1 938	49.01	1 829	50.99	3 767	100
	South Africa	8 783	81.66	2 177	18.34	10 960	100
Lower	United Arab Emirates	12 079	90.53	1 264	9.47	13 343	100
	Thailand	4 737	79.54	1 211	20.46	5 948	100
	Singapore	4 472	77.02	1 384	22.98	5 856	100

Education mathematics as a major area of study

		Yes		No		Total	
Status	Names of countries	N of cases	%	N of cases	%	N of cases	%
Higher government expenditure on education	Saudi Arabia	2 779	68.47	1 402	31.53	4 181	100
	Sweden	2 889	62.43	1 792	37.57	4 681	100
	Norway	392	11.38	3 331	88.62	3 723	100
	South Africa	4 195	36.35	6 617	63.65	10 812	100
Lower government expenditure on education	United Arab Emirates	6 101	44.29	7 306	55.71	13 407	100
	Thailand	999	18.78	4 949	81.22	5 948	100
	Singapore	2 184	38.27	3 617	61.73	5 801	100

8.7 Annexure I: Computer activities in the classrooms

BTBM22CA **Computer activities - principles and concepts**

		Once or twice a week		Once or twice a week		Once or twice a month		Never or almost never	
Status	Names of countries	N of cases	%	N of cases	%	N of cases	%	N of cases	%
Higher	Saudi Arabia	47	6.51	264	33.97	256	33.10	237	26.42
	Sweden	33	1.79	70	5.07	582	33.65	1 198	59.49
	Norway	0	0	57	1.87	1212	42.59	1 438	55.53
	South Africa	118	11.21	217	10.69	277	14.11	1 401	63.99
Lower	United Arab Emirates	593	16.79	1 292	29.98	1 910	42.33	448	10.89
	Thailand	87	5.48	267	18.38	528	45.06	323	31.08
	Singapore	38	1.16	218	7.04	1 949	59.20	1 063	32.60

BTBM22CB **Computer activities – skills and procedures**

		Once or twice a week		Once or twice a week		Once or twice a month		Never or almost never	
Status	Names of countries	N of cases	%	N of cases	%	N of cases	%	N of cases	%
Higher	Saudi Arabia	76	9.14	271	36.11	282	35.18	175	19.56
	Sweden	29	1.67	171	9.74	967	52.76	718	35.83
	Norway	0	0	45	1.60	1 919	67.98	760	30.42
	South Africa	121	11.29	252	13.06	193	10.69	1 447	64.95
Lower	United Arab Emirates	612	17.40	1 507	35.20	1 796	39.34	325	8.05
	Thailand	87	5.48	194	18.12	781	66.68	143	9.73
	Singapore	57	1.76	239	7.43	1 706	51.91	1 266	38.91

BTBM22CC **Computer activities – look up ideas and information**

		Once or twice a week		Once or twice a week		Once or twice a month		Never or almost never	
GDP Status	Names of countries	N of cases	%	N of cases	%	N of cases	%	N of cases	%
Higher GDP	Saudi Arabia	95	10.60	230	31.81	326	41.40	153	16.19
	Sweden	49	4.04	68	4.87	543	27.67	1225	57.76
	Norway	0	0	67	2.47	1 123	40.16	1 559	57.38
	South Africa	163	11.73	181	9.21	504	21.30	1 165	57.76
Lower GDP	United Arab Emirates	457	11.74	1 331	29.61	2000	47.35	480	11.31
	Thailand	87	5.48	245	23.34	791	68.00	82	3.18
	Singapore	201	5.88	0	0	1 319	41.54	1 748	52.59

BTBM22CD **Computer activities – process and analyse data**

		Once or twice a week		Once or twice a week		Once or twice a month		Never or almost never	
Status	Names of countries	N of cases	%	N of cases	%	N of cases	%	N of cases	%
Higher	Saudi Arabia	26	1.35	188	26.15	328	42.72	262	29.78
	Sweden	13	0.82	65	4.86	591	31.04	1 214	63.28
	Norway	0	0	92	4.12	1952	71.99	667	23.88
	South Africa	163	11.73	178	9.13	338	16.37	1 334	62.77
Lower	United Arab Emirates	334	9.62	947	25.01	1 882	40.43	1 077	24.94
	Thailand	87	5.48	222	21.25	450	30.40	446	42.87
	Singapore	111	3.25	0	0	1 256	39.17	1 901	57.57

8.8 Annexure J: Computer activities (SPSS and Orthosim outputs)

SAUDI ARABIA AND SOUTH AFRICA

SPSS Outputs - Component loadings				
Variables	Saudi Arabia		South Africa	
	TARGET factor/coordinate matrix		COMPARISON factor/coordinate matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
BTM9BA	-0.5240	0.3376	-0.4817	0.7252
BTM9BB	-0.7465	0.5218	-0.1164	0.8686
BTM9BC	-0.5588	0.6244	0.0751	0.8562
BTBM22CA	0.5529	0.7144	0.9269	0.1285
BTBM22CB	0.6399	0.6354	0.9304	0.0876
BTBM22CC	0.3482	0.5443	0.9315	0.0913
BTBM22CD	0.8474	-0.0896	0.9304	0.0997

Orthosim Outputs - Rotated component loadings					
Variables	Saudi Arabia		South Africa		Similarity index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix		Orthogonalised Maximally Congruent Comparison Matrix: SPSS		
	Factor 1	Factor 2	Factor 1	Factor 2	Ø
BTM9BA	-0.5240	0.3376	-0.8108	0.3169	0.980
BTM9BB	-0.7465	0.5218	-0.5942	0.6441	0.976
BTM9BC	-0.5588	0.6244	-0.4303	0.7440	0.978
BTBM22CA	0.5529	0.7144	0.6849	0.6375	0.986
BTBM22CB	0.6399	0.6354	0.7113	0.6062	0.997
BTBM22CC	0.3482	0.5443	0.7101	0.6098	0.957
BTBM22CD	0.8474	-0.0896	0.7043	0.6160	0.679
Overall congruent coefficient					**0.936**

SWEDEN AND SOUTH AFRICA

SPSS Outputs - Component loadings				
Variables	Sweden		South Africa	
	TARGET factor/coordinate matrix		COMPARISON factor/coordinate matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
BTM9BA	0.2277	0.4294	-0.4817	0.7252
BTM9BB	0.0944	0.8501	-0.1164	0.8686
BTM9BC	0.2594	0.8295	0.0751	0.8562
BTBM22CA	0.9120	-0.0873	0.9269	0.1285
BTBM22CB	0.7602	-0.1254	0.9304	0.0876
BTBM22CC	0.8698	-0.1702	0.9315	0.0913
BTBM22CD	0.9209	-0.0767	0.9304	0.0997

Orthosim Outputs - Rotated component loadings					
Variables	Sweden		South Africa		Similarity index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix		Orthogonalised Maximally Congruent Comparison Matrix: SPSS		
	Factor 1	Factor 2	Factor 1	Factor 2	Ø
BTM9BA	-0.4817	0.7252	0.2277	0.4294	0.715
BTM9BB	-0.1164	0.8686	0.0944	0.8501	0.998
BTM9BC	0.0751	0.8562	0.2594	0.8295	0.996
BTBM22CA	0.9269	0.1285	0.9120	-0.0873	0.997
BTBM22CB	0.9304	0.0876	0.7602	-0.1254	0.999
BTBM22CC	0.9315	0.0913	0.8698	-0.1702	0.999
BTBM22CD	0.9304	0.0997	0.9209	-0.0767	0.993
Overall congruent coefficient					**0.957**

NORWAY AND SOUTH AFRICA

SPSS Outputs - Component loadings				
Variables	Norway		South Africa	
	TARGET factor/coordinate matrix		COMPARISON factor/coordinate matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
BTM9BA	0.5408	0.3750	-0.4817	0.7252
BTM9BB	0.3601	0.7864	-0.1164	0.8686
BTM9BC	0.4232	0.7917	0.0751	0.8562
BTBM22CA	0.6047	-0.3782	0.9269	0.1285
BTBM22CB	0.6632	-0.2776	0.9304	0.0876
BTBM22CC	0.6523	-0.3727	0.9315	0.0913
BTBM22CD	0.6224	-0.2654	0.9304	0.0997

Orthosim Outputs - Rotated component loadings					
Variables	Norway		South Africa		Similarity index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix		Orthogonalised Maximally Congruent Comparison Matrix: SPSS		
	Factor 1	Factor 2	Factor 1	Factor 2	Ø
BTM9BA	0.5408	0.3750	0.0567	0.8687	0.622
BTM9BB	0.3601	0.7864	0.4342	0.7613	0.996
BTM9BC	0.4232	0.7917	0.5789	0.6352	0.969
BTBM22CA	0.6047	-0.3782	0.8149	-0.4599	0.998
BTBM22CB	0.6632	-0.2776	0.7930	-0.4946	0.987
BTBM22CC	0.6523	-0.3727	0.7960	-0.4923	0.999
BTBM22CD	0.6224	-0.2654	0.8002	-0.4850	0.989
Overall congruent coefficient					**0.937**

THAILAND AND SOUTH AFRICA

SPSS Outputs - Component loadings				
Variables	Thailand		South Africa	
	TARGET factor/coordinate matrix		COMPARISON factor/coordinate matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
BTM9BA	0.2381	0.6024	-0.4817	0.7252
BTM9BB	-0.0139	0.9260	-0.1164	0.8686
BTM9BC	0.0677	0.9531	0.0751	0.8562
BTBM22CA	0.9972	-0.0472	0.9269	0.1285
BTBM22CB	0.9972	-0.0510	0.9304	0.0876
BTBM22CC	0.9972	-0.0563	0.9315	0.0913
BTBM22CD	0.9980	-0.0411	0.9304	0.0997

Orthosim Outputs - Rotated component loadings					
Variables	Thailand		South Africa		Similarity index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix		Orthogonalised Maximally Congruent Comparison Matrix: SPSS		
	Factor 1	Factor 2	Factor 1	Factor 2	Ø
BTM9BA	0.2381	0.6024	-0.3295	0.8058	0.721
BTM9BB	-0.0139	0.9260	0.0569	0.8745	0.996
BTM9BC	0.0677	0.9531	0.2422	0.8246	0.977
BTBM22CA	0.9972	-0.0472	0.9340	-0.0566	0.999
BTBM22CB	0.9972	-0.0510	0.9295	-0.0974	0.998
BTBM22CC	0.9972	-0.0563	0.9312	-0.0940	0.999
BTBM22CD	0.9980	-0.0411	0.9318	-0.0855	0.998
Overall congruent coefficient					**0.955**

UNITED ARAB EMIRATES AND SOUTH AFRICA

SPSS Outputs - Component loadings				
Variables	United Arab Emirates		South Africa	
	TARGET factor/coordinate matrix		COMPARISON factor/coordinate matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
BTM9BA	0.3537	0.3609	-0.4817	0.7252
BTM9BB	0.1524	0.8344	-0.1164	0.8686
BTM9BC	0.2981	0.8386	0.0751	0.8562
BTBM22CA	0.8373	-0.0899	0.9269	0.1285
BTBM22CB	0.8315	-0.1503	0.9304	0.0876
BTBM22CC	0.8098	-0.2391	0.9315	0.0913
BTBM22CD	0.8793	-0.1260	0.9304	0.0997

Orthosim Outputs - Rotated component loadings					
Variables	United Arab Emirates		South Africa		Similarity index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix		Orthogonalised Maximally Congruent Comparison Matrix: SPSS		
	Factor 1	Factor 2	Factor 1	Factor 2	Ø
BTM9BA	0.3537	0.3609	-0.1913	0.8493	0.542
BTM9BB	0.1524	0.8344	0.2011	0.8530	0.998
BTM9BC	0.2981	0.8386	0.3756	0.7730	0.993
BTBM22CA	0.8373	-0.0899	0.9117	-0.2106	0.992
BTBM22CB	0.8315	-0.1503	0.9005	-0.2501	0.995
BTBM22CC	0.8098	-0.2391	0.9028	-0.2470	0.999
BTBM22CD	0.8793	-0.1260	0.9047	-0.2388	0.993
Overall congruent coefficient					**0.931**

SINGAPORE AND SOUTH AFRICA

SPSS Outputs - Component loadings				
Variables	Singapore		South Africa	
	TARGET factor/coordinate matrix		COMPARISON factor/coordinate matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
BTM9BA	0.2616	0.6679	-0.4817	0.7252
BTM9BB	0.2689	0.8093	-0.1164	0.8686
BTM9BC	0.2910	0.8690	0.0751	0.8562
BTBM22CA	0.8492	-0.2109	0.9269	0.1285
BTBM22CB	0.8325	-0.2274	0.9304	0.0876
BTBM22CC	0.8360	-0.1335	0.9315	0.0913
BTBM22CD	0.8450	-0.1959	0.9304	0.0997

Orthosim Outputs - Rotated component loadings					
Variables	Singapore		South Africa		Similarity index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix		Orthogonalised Maximally Congruent Comparison Matrix: SPSS		
	Factor 1	Factor 2	Factor 1	Factor 2	Ø
BTM9BA	0.2616	0.6679	-0.1566	0.8564	0.850
BTM9BB	0.2689	0.8093	0.2357	0.8441	0.998
BTM9BC	0.2910	0.8690	0.4068	0.7571	0.985
BTBM22CA	0.8492	-0.2109	0.9024	-0.2476	0.999
BTBM22CB	0.8325	-0.2274	0.8895	-0.2865	0.998
BTBM22CC	0.8360	-0.1335	0.8920	-0.2836	0.988
BTBM22CD	0.8450	-0.1959	0.8942	-0.2755	0.997
Overall congruent coefficient					**0.974**

8.9 Annexure K: Teaching strategies (SPSS and Orthosim outputs)

SAUDI ARABIA AND SOUTH AFRICA

SPSS Outputs - Component loadings						
Variables	Saudi Arabia			South Africa		
	TARGET factor/coordinate matrix			COMPARISON factor/coordinate matrix		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
BTBM19A	0.2644	-0.5052	0.5918	0.4441	0.5179	-0.2421
BTBM19B	0.5102	-0.3947	-0.1826	0.5557	0.3982	-0.3912
BTBM19C	0.5616	0.5291	0.1543	0.5802	0.2399	-0.1360
BTBM19D	0.3675	0.4991	0.5348	0.6271	0.3874	0.1856
BTBM19E	0.5373	0.3863	-0.1270	0.5471	-0.3273	-0.2815
BTBM19F	0.5660	-0.3773	-0.1056	0.5192	0.2639	0.4029
BTBM19G	0.5941	-0.4222	-0.2190	0.3881	-0.0895	0.6365
BTBM19H	0.5016	-0.0912	0.1896	0.5296	-0.1606	-0.0288
BTBM19I	0.6048	0.2686	-0.4067	0.4929	-0.5328	-0.0914
BTBM19J	0.6481	0.0862	-0.2132	0.5690	-0.5565	-0.2150
BTBM19K	0.4541	-0.1355	0.4414	0.4616	-0.1998	0.3636

Orthosim Outputs - Rotated component loadings							
Variables	Saudi Arabia			South Africa			Similarity Index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix			Orthogonalised Maximally Congruent Comparison Matrix: SPSS			
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Ø
BTBM19A	0.2644	-0.5052	0.5918	0.3185	0.0970	0.6428	0.698
BTBM19B	0.5102	-0.3947	-0.1826	0.4310	0.2818	0.5960	-0.000
BTBM19C	0.5102	-0.3947	-0.1826	0.5112	0.0892	0.3785	0.777
BTBM19D	0.3675	0.4991	0.5348	0.5689	-0.2588	0.4326	0.500
BTBM19E	0.5373	0.3863	-0.1270	0.5590	0.3995	-0.1169	0.999
BTBM19F	0.5660	-0.3773	-0.1056	0.5093	-0.4336	0.2327	0.876
BTBM19G	0.5941	-0.4222	-0.2190	0.4681	-0.5548	-0.1918	0.970
BTBM19H	0.5016	-0.0912	0.1896	0.5424	0.1073	-0.0375	0.846
BTBM19I	0.6048	0.2686	-0.4067	0.5628	0.2787	-0.3752	0.999
BTBM19J	0.6481	0.0862	-0.2132	0.6272	0.4079	-0.3465	0.909
BTBM19K	0.4541	-0.1355	0.4414	0.5276	-0.2575	-0.2015	0.461
Overall congruent coefficient							**0.731**

SWEDEN AND SOUTH AFRICA

SPSS Outputs - Component loadings						
Variables	Sweden			South Africa		
	TARGET factor/coordinate matrix			COMPARISON factor/coordinate matrix		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
BTBM19A	0.3988	-0.3425	-0.5877	0.4441	0.5179	-0.2421
BTBM19B	0.5923	-0.0596	-0.4722	0.5557	0.3982	-0.3912
BTBM19C	0.6024	-0.3055	0.1598	0.5802	0.2399	-0.1360
BTBM19D	0.5699	0.0685	-0.1429	0.6271	0.3874	0.1856
BTBM19E	0.4617	0.6680	-0.0830	0.5471	-0.3273	-0.2815
BTBM19F	0.5815	-0.2456	-0.0820	0.5192	0.2639	0.4029
BTBM19G	0.5525	-0.4193	0.3185	0.3881	-0.0895	0.6365
BTBM19H	0.5453	-0.0275	-0.0291	0.5296	-0.1606	-0.0288
BTBM19I	0.6087	0.0479	0.4418	0.4929	-0.5328	-0.0914
BTBM19J	0.6024	0.2281	0.4140	0.5690	-0.5565	-0.2150
BTBM19K	0.4268	0.5423	-0.2183	0.4616	-0.1998	0.3636

Orthosim Outputs - Rotated component loadings							
Variables	Sweden			South Africa			Similarity Index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix			Orthogonalised Maximally Congruent Comparison Matrix: SPSS			
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Ø
BTBM19A	0.3988	-0.3425	-0.5877	0.4102	-0.1248	-0.5833	0.962
BTBM19B	0.5923	-0.0596	-0.4722	0.5104	0.0722	-0.5956	0.967
BTBM19C	0.6024	-0.3055	0.1598	0.5607	-0.0190	-0.3128	0.658
BTBM19D	0.5699	0.0685	-0.1429	0.6332	-0.3567	-0.2228	0.819
BTBM19E	0.4617	0.6680	-0.0830	0.5263	0.4559	0.0298	0.958
BTBM19F	0.5815	-0.2456	-0.0820	0.5476	-0.4487	0.0187	0.947
BTBM19G	0.5525	-0.4193	0.3185	0.4451	-0.4061	0.4480	0.975
BTBM19H	0.5453	-0.0275	-0.0291	0.5281	0.1548	0.0656	0.929
BTBM19I	0.6087	0.0479	0.4418	0.4935	0.4404	0.3126	0.833
BTBM19J	0.6024	0.2281	0.4140	0.5587	0.5542	0.2459	0.894
BTBM19K	0.4268	0.5423	-0.2183	0.4962	-0.1229	0.3520	0.151
Overall congruent coefficient							**0.827**

NORWAY AND SOUTH AFRICA

SPSS Outputs - Component loadings						
Variables	Norway			South Africa		
	TARGET factor/coordinate matrix			COMPARISON factor/coordinate matrix		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
BTBM19A	0.1909	-0.5770	-0.4095	0.4441	0.5179	-0.2421
BTBM19B	0.6581	-0.1653	-0.1630	0.5557	0.3982	-0.3912
BTBM19C	0.2029	-0.7349	-0.3304	0.5802	0.2399	-0.1360
BTBM19D	0.6862	0.3199	-0.0134	0.6271	0.3874	0.1856
BTBM19E	-0.0097	-0.1612	0.5742	0.5471	-0.3273	-0.2815
BTBM19F	0.3642	0.6269	-0.1063	0.5192	0.2639	0.4029
BTBM19G	0.8454	-0.0614	-0.0830	0.3881	-0.0895	0.6365
BTBM19H	0.4326	-0.3234	0.2407	0.5296	-0.1606	-0.0288
BTBM19I	0.7174	0.1973	0.2721	0.4929	-0.5328	-0.0914
BTBM19J	0.0548	-0.3993	0.6535	0.5690	-0.5565	-0.2150
BTBM19K	0.0826	-0.1276	0.4955	0.4616	-0.1998	0.3636

Orthosim Outputs - Rotated component loadings							
Variables	Norway			South Africa			Similarity Index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix			Orthogonalised Maximally Congruent Comparison Matrix: SPSS			
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Ø
BTBM19A	0.1909	-0.5770	-0.4095	0.4190	-0.4292	-0.4052	0.930
BTBM19B	0.6581	-0.1653	-0.1630	0.4396	-0.5981	-0.2636	0.784
BTBM19C	0.2029	-0.7349	-0.3304	0.5239	-0.3568	-0.1039	0.754
BTBM19D	0.6862	0.3199	-0.0134	0.7168	-0.0878	-0.2373	0.811
BTBM19E	-0.0097	-0.1612	0.5742	0.3220	-0.4324	0.4416	0.770
BTBM19F	0.3642	0.6269	-0.1063	0.6745	0.1634	-0.1412	0.699
BTBM19G	0.8454	-0.0614	-0.0830	0.5695	0.4573	0.1738	0.686
BTBM19H	0.4326	-0.3234	0.2407	0.4350	-0.2055	0.2751	0.979
BTBM19I	0.7174	0.1973	0.2721	0.4350	-0.2055	0.2751	0.593
BTBM19J	0.0548	-0.3993	0.6535	0.3191	-0.3595	0.6699	0.945
BTBM19K	0.0826	-0.1276	0.4955	0.5115	0.1866	0.2979	0.516
Overall congruent coefficient							**0.770**

THAILAND AND SOUTH AFRICA

SPSS Outputs - Component loadings						
Variables	Thailand			South Africa		
	TARGET factor/coordinate matrix			COMPARISON factor/coordinate matrix		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
BTBM19A	0.6057	-0.4122	0.4439	0.4441	0.5179	-0.2421
BTBM19B	0.5191	-0.3625	0.5950	0.5557	0.3982	-0.3912
BTBM19C	0.3646	0.8614	0.1392	0.5802	0.2399	-0.1360
BTBM19D	0.2703	0.8135	0.0593	0.6271	0.3874	0.1856
BTBM19E	0.5686	-0.2259	-0.1950	0.5471	-0.3273	-0.2815
BTBM19F	0.5330	0.7398	0.1257	0.5192	0.2639	0.4029
BTBM19G	0.7460	0.0790	-0.0308	0.3881	-0.0895	0.6365
BTBM19H	0.5373	-0.1414	-0.4368	0.5296	-0.1606	-0.0288
BTBM19I	0.8540	-0.2255	-0.1369	0.4929	-0.5328	-0.0914
BTBM19J	0.7192	-0.2173	-0.0321	0.5690	-0.5565	-0.2150
BTBM19K	0.4113	0.0070	-0.4935	0.4616	-0.1998	0.3636

Orthosim Outputs - Rotated component loadings							
Variables	Thailand			South Africa			Similarity Index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix			Orthogonalised Maximally Congruent Comparison Matrix: SPSS			
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Ø
BTBM19A	0.6057	-0.4122	0.4439	0.3602	0.1758	0.6028	0.666
BTBM19B	0.5191	-0.3625	0.5950	0.5053	0.0087	0.6041	0.903
BTBM19C	0.3646	0.8614	0.1392	0.5353	0.1306	0.3302	0.582
BTBM19D	0.2703	0.8135	0.0593	0.5242	0.4816	0.2666	0.840
BTBM19E	0.5686	-0.2259	-0.1950	0.6220	-0.3110	-0.0460	0.967
BTBM19F	0.5330	0.7398	0.1257	0.4217	0.5682	0.0297	0.995
BTBM19G	0.7460	0.0790	-0.0308	0.3378	0.5348	-0.4044	0.544
BTBM19H	0.5373	-0.1414	-0.4368	0.5506	-0.0166	-0.0604	0.828
BTBM19I	0.8540	-0.2255	-0.1369	0.5898	-0.2825	-0.3279	0.936
BTBM19J	0.7192	-0.2173	-0.0321	0.6800	-0.3818	-0.2675	0.936
BTBM19K	0.4113	0.0070	-0.4935	0.4554	0.2660	-0.3273	0.879
Overall congruent coefficient							**0.825**

UNITED ARAB EMIRATES AND SOUTH AFRICA

SPSS Outputs - Component loadings						
Variables	United Arab Emirates			South Africa		
	TARGET factor/coordinate matrix			COMPARISON factor/coordinate matrix		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
BTBM19A	0.4131	-0.4232	0.1317	0.7036	0.3737	0.6044
BTBM19B	0.4486	-0.4087	0.4163	0.8097	-0.1581	0.5652
BTBM19C	0.5568	-0.2984	-0.2223	0.7614	-0.6172	-0.1983
BTBM19D	0.6047	-0.3847	-0.1484	0.3941	0.4905	-0.7772
BTBM19E	0.5142	-0.2574	-0.4361	0.5246	-0.8278	-0.1989
BTBM19F	0.6075	-0.1420	0.2175	0.8343	-0.5252	-0.1679
BTBM19G	0.4699	0.2728	0.4302	0.9508	0.3053	0.0531
BTBM19H	0.4072	0.5649	0.1916	0.7577	0.0967	0.6454
BTBM19I	0.5782	0.4284	-0.3745	0.7305	0.0200	-0.6826
BTBM19J	0.5820	0.4757	-0.2736	0.8217	0.5406	-0.1806
BTBM19K	0.4156	0.2233	0.3851	0.5529	-0.8135	-0.1804

Orthosim Outputs - Rotated component loadings							
Variables	United Arab Emirates			South Africa			Similarity Index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix			Orthogonalised Maximally Congruent Comparison Matrix: SPSS			
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Ø
BTBM19A	0.4131	-0.4232	0.1317	0.4201	-0.5894	0.0134	0.968
BTBM19B	0.4486	-0.4087	0.4163	0.5313	-0.5547	-0.1748	0.676
BTBM19C	0.5568	-0.2984	-0.2223	0.5680	-0.2993	-0.0190	0.952
BTBM19D	0.6047	-0.3847	-0.1484	0.6192	-0.2877	0.3340	0.782
BTBM19E	0.5142	-0.2574	-0.4361	0.5492	0.1420	-0.4049	0.839
BTBM19F	0.6075	-0.1420	0.2175	0.5216	-0.0751	0.4731	0.919
BTBM19G	0.4699	0.2728	0.4302	0.4086	0.3508	0.5232	0.985
BTBM19H	0.4072	0.5649	0.1916	0.5335	0.1081	-0.1039	0.645
BTBM19I	0.5782	0.4284	-0.3745	0.5071	0.4132	-0.3276	0.999
BTBM19J	0.5820	0.4757	-0.2736	0.5804	0.3753	-0.4494	0.969
BTBM19K	0.4156	0.2233	0.3851	0.4780	0.3229	0.2291	0.949
Overall congruent coefficient							**0.881**

SINGAPORE AND SOUTH AFRICA

SPSS Outputs - Component loadings						
Variables	Singapore			South Africa		
	TARGET factor/coordinate matrix			COMPARISON factor/coordinate matrix		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
BTBM19A	0.4813	0.5213	-0.4031	0.7036	0.3737	0.6044
BTBM19B	0.5712	0.3107	-0.5627	0.8097	-0.1581	0.5652
BTBM19C	0.5462	0.3813	0.4963	0.7614	-0.6172	-0.1983
BTBM19D	0.5914	0.5337	0.2990	0.3941	0.4905	-0.7772
BTBM19E	0.5731	-0.0685	0.3299	0.5246	-0.8278	-0.1989
BTBM19F	0.5676	0.3596	-0.1106	0.8343	-0.5252	-0.1679
BTBM19G	0.5528	-0.0655	0.2263	0.9508	0.3053	0.0531
BTBM19H	0.6116	-0.3667	-0.1061	0.7577	0.0967	0.6454
BTBM19I	0.5823	-0.4649	0.0531	0.7305	0.0200	-0.6826
BTBM19J	0.6900	-0.5114	-0.0235	0.8217	0.5406	-0.1806
BTBM19K	0.5978	-0.3897	-0.2237	0.5529	-0.8135	-0.1804

Orthosim Outputs - Rotated component loadings							
Variables	Singapore			South Africa			Similarity Index
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix			Orthogonalised Maximally Congruent Comparison Matrix: SPSS			
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Ø
BTBM19A	0.4813	0.5213	-0.4031	0.4042	0.5076	-0.3209	0.996
BTBM19B	0.5712	0.3107	-0.5627	0.5226	0.3760	-0.4538	0.990
BTBM19C	0.5462	0.3813	0.4963	0.5605	0.2575	-0.1793	0.591
BTBM19D	0.5914	0.5337	0.2990	0.5998	0.4519	0.1174	0.975
BTBM19E	0.5731	-0.0685	0.3299	0.5663	-0.3256	-0.2430	0.575
BTBM19F	0.5676	0.3596	-0.1106	0.5029	0.3533	0.3519	0.774
BTBM19G	0.5528	-0.0655	0.2263	0.3992	0.0285	0.6353	0.803
BTBM19H	0.6116	-0.3667	-0.1061	0.5393	-0.1263	-0.0159	0.945
BTBM19I	0.5823	-0.4649	0.0531	0.5285	-0.5053	-0.0248	0.990
BTBM19J	0.6900	-0.5114	-0.0235	0.6050	-0.5410	-0.1454	0.984
BTBM19K	0.5978	-0.3897	-0.2237	0.4779	-0.1141	0.3793	0.528
Overall congruent coefficient							**0.832**

8.10 Annexure L: Content coverage (SPSS and Orthosim outputs)

SAUDI ARABIA AND SOUTH AFRICA

SPSS Outputs - Component loadings										
Variables	Saudi Arabia					South Africa				
	TARGET factor/coordinate matrix					COMPARISON factor/coordinate matrix				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	-0.222	0.724	0.255	-0.097	-0.103	0.715	0.379	0.005	-0.266	0.395
BTBM30AB	-0.398	0.535	0.104	-0.370	-0.324	0.113	0.431	-0.430	0.574	0.141
BTBM30AC	-0.427	0.667	0.077	-0.074	-0.331	0.974	-0.033	-0.112	-0.060	-0.046
BTBM30AD	-0.264	0.649	0.253	-0.113	-0.065	0.775	-0.154	0.420	0.373	0.069
BTBM30AE	-0.471	0.519	-0.115	0.319	-0.181	0.072	0.719	0.330	-0.063	-0.413
BTBM30BA	0.334	0.605	-0.013	0.162	0.432	0.925	-0.086	0.068	0.002	0.014
BTBM30BB	-0.635	0.270	-0.071	0.355	0.102	0.583	0.281	0.175	-0.309	0.495
BTBM30BC	0.225	0.323	-0.173	0.348	-0.600	0.096	0.498	-0.438	0.526	0.117
BTBM30BD	0.098	0.260	0.422	0.585	0.313	0.789	-0.096	-0.238	-0.048	-0.388
BTBM30BE	0.702	0.076	0.234	-0.221	-0.016	0.975	-0.063	-0.100	-0.073	-0.080
BTBM30CA	-0.493	0.415	0.170	-0.152	0.361	0.974	-0.040	-0.114	-0.060	-0.046
BTBM30CB	-0.584	0.504	0.047	-0.279	0.328	0.974	-0.045	-0.107	-0.064	-0.050
BTBM30CC	0.632	0.276	0.410	-0.121	-0.015	0.628	-0.075	0.513	0.403	-0.013
BTBM30CD	0.708	0.042	0.368	-0.297	-0.037	-0.081	0.759	0.314	-0.143	-0.310
BTBM30CE	0.422	0.071	0.624	0.321	-0.163	0.788	-0.052	-0.237	-0.038	-0.402
BTBM30CF	0.703	0.426	-0.122	0.093	-0.039	0.974	-0.042	-0.108	-0.061	-0.049
BTBM30DA	0.496	0.556	-0.457	-0.005	-0.009	0.774	-0.147	0.427	0.380	0.064
BTBM30DB	0.489	0.543	-0.316	0.060	0.205	0.815	0.251	-0.058	-0.189	0.286
BTBM30DC	0.596	0.524	-0.447	-0.116	0.081	0.974	-0.036	-0.109	-0.063	-0.048

Orthosim Outputs - Rotated component loadings										
Variables	Saudi Arabia					South Africa				
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix					Orthogonalised Maximally Congruent Comparison Matrix: SPSS				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	-0.222	0.724	0.255	-0.097	-0.103	-0.368	0.846	0.041	-0.020	0.160
BTBM30AB	-0.398	0.535	0.104	-0.370	-0.324	-0.014	0.319	-0.229	0.181	-0.738
BTBM30AC	-0.427	0.667	0.077	-0.074	-0.331	0.275	0.873	0.087	0.231	0.263
BTBM30AD	-0.264	0.649	0.253	-0.113	-0.065	0.521	0.698	-0.076	-0.404	0.129
BTBM30AE	-0.471	0.519	-0.115	0.319	-0.181	-0.147	0.168	0.771	-0.229	-0.331
BTBM30BA	0.334	0.605	-0.013	0.162	0.432	0.311	0.827	0.042	0.033	0.291
BTBM30BB	-0.635	0.270	-0.071	0.355	0.102	-0.410	0.713	-0.024	-0.198	0.269
BTBM30BC	0.225	0.323	-0.173	0.348	-0.600	-0.070	0.315	-0.167	0.199	-0.754
BTBM30BD	0.098	0.260	0.422	0.585	0.313	0.436	0.606	0.254	0.429	0.188
BTBM30BE	0.702	0.076	0.234	-0.221	-0.016	0.303	0.856	0.105	0.235	0.290
BTBM30CA	-0.493	0.415	0.170	-0.152	0.361	0.277	0.872	0.082	0.232	0.267
BTBM30CB	-0.584	0.504	0.047	-0.279	0.328	0.281	0.869	0.086	0.228	0.274
BTBM30CC	0.632	0.276	0.410	-0.121	-0.015	0.508	0.566	0.027	-0.495	0.041
BTBM30CD	0.708	0.042	0.368	-0.297	-0.037	-0.315	0.059	0.725	-0.244	-0.332
BTBM30CE	0.422	0.071	0.624	0.321	-0.163	0.424	0.616	0.282	0.426	0.153
BTBM30CF	0.703	0.426	-0.122	0.093	-0.039	0.280	0.871	0.085	0.228	0.270
BTBM30DA	0.496	0.556	-0.457	-0.005	-0.009	0.524	0.699	-0.069	-0.411	0.121
BTBM30DB	0.489	0.543	-0.316	0.060	0.205	-0.174	0.883	0.023	0.072	0.183
BTBM30DC	0.596	0.524	-0.447	-0.116	0.081	0.275	0.873	0.088	0.229	0.267

SWEDEN AND SOUTH AFRICA

SPSS Outputs - Component loadings										
Variables	Sweden					South Africa				
	TARGET factor/coordinate matrix					COMPARISON factor/coordinate matrix				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.583	-0.298	0.504	0.464	0.005	0.715	0.379	0.005	-0.266	0.395
BTBM30AB	0.444	0.073	0.629	-0.566	-0.223	0.113	0.431	-0.430	0.574	0.141
BTBM30AC	0.477	-0.215	0.598	0.153	-0.010	0.974	-0.033	-0.112	-0.060	-0.046
BTBM30AD	0.575	-0.315	0.474	0.464	-0.004	0.775	-0.154	0.420	0.373	0.069
BTBM30AE	0.433	0.062	0.626	-0.579	-0.224	0.072	0.719	0.330	-0.063	-0.413
BTBM30BA	0.667	-0.071	0.011	0.247	0.333	0.925	-0.086	0.068	0.002	0.014
BTBM30BB	0.472	0.246	-0.081	-0.256	0.532	0.583	0.281	0.175	-0.309	0.495
BTBM30BC	0.660	-0.201	-0.181	-0.018	0.266	0.096	0.498	-0.438	0.526	0.117
BTBM30BD	0.783	-0.132	-0.402	-0.037	-0.200	0.789	-0.096	-0.238	-0.048	-0.388
BTBM30BE	0.709	-0.025	-0.242	-0.196	0.118	0.975	-0.063	-0.100	-0.073	-0.080
BTBM30CA	0.332	0.598	0.118	-0.322	0.259	0.974	-0.040	-0.114	-0.060	-0.046
BTBM30CB	0.719	0.208	-0.293	-0.069	0.087	0.974	-0.045	-0.107	-0.064	-0.050
BTBM30CC	0.778	-0.048	-0.352	-0.008	-0.239	0.628	-0.075	0.513	0.403	-0.013
BTBM30CD	0.578	-0.073	0.221	0.032	0.360	-0.081	0.759	0.314	-0.143	-0.310
BTBM30CE	0.706	-0.235	-0.246	-0.064	-0.285	0.788	-0.052	-0.237	-0.038	-0.402
BTBM30CF	0.775	-0.156	-0.403	-0.042	-0.276	0.974	-0.042	-0.108	-0.061	-0.049
BTBM30DA	0.250	0.721	0.095	0.295	-0.179	0.774	-0.147	0.427	0.380	0.064
BTBM30DB	0.420	0.630	-0.002	0.258	-0.157	0.815	0.251	-0.058	-0.189	0.286
BTBM30DC	0.191	0.803	0.091	0.339	-0.117	0.974	-0.036	-0.109	-0.063	-0.048

Orthosim Outputs - Rotated component loadings										
Variables	Sweden					South Africa				
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix					Orthogonalised Maximally Congruent Comparison Matrix: SPSS				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.583	-0.298	0.504	0.464	0.005	0.674	0.382	0.203	0.064	0.485
BTBM30AB	0.444	0.073	0.629	-0.566	-0.223	0.186	0.343	0.354	-0.604	-0.299
BTBM30AC	0.477	-0.215	0.598	0.153	-0.010	0.921	0.239	-0.224	0.113	0.012
BTBM30AD	0.575	-0.315	0.474	0.464	-0.004	0.674	0.221	0.180	0.518	-0.376
BTBM30AE	0.433	0.062	0.626	-0.579	-0.224	0.336	-0.604	0.517	-0.164	0.185
BTBM30BA	0.667	-0.071	0.011	0.247	0.333	0.846	0.240	-0.124	0.277	-0.043
BTBM30BB	0.472	0.246	-0.081	-0.256	0.532	0.501	0.383	0.243	0.250	0.519
BTBM30BC	0.660	-0.201	-0.181	-0.018	0.266	0.192	0.298	0.374	-0.646	-0.240
BTBM30BD	0.783	-0.132	-0.402	-0.037	-0.200	0.810	-0.039	-0.404	-0.059	-0.16
BTBM30BE	0.709	-0.025	-0.242	-0.196	0.118	0.922	0.210	-0.253	0.133	0.002
BTBM30CA	0.332	0.598	0.118	-0.322	0.259	0.919	0.242	-0.228	0.115	0.011
BTBM30CB	0.719	0.208	-0.293	-0.069	0.087	0.919	0.237	-0.231	0.123	0.010
BTBM30CC	0.778	-0.048	-0.352	-0.008	-0.239	0.573	0.072	0.285	0.503	-0.397
BTBM30CD	0.578	-0.073	0.221	0.032	0.360	0.177	-0.575	0.553	-0.193	0.304
BTBM30CE	0.706	-0.235	-0.246	-0.064	-0.285	0.824	-0.057	-0.372	-0.086	-0.122
BTBM30CF	0.775	-0.156	-0.403	-0.042	-0.276	0.919 5	0.238	-0.228	0.120	0.009
BTBM30DA	0.250	0.721	0.095	0.295	-0.179	0.676	0.214	0.190	0.518	-0.380
BTBM30DB	0.420	0.630	-0.002	0.258	-0.157	0.764	0.379	0.069	0.065	0.336
BTBM30DC	0.191	0.803	0.090	0.339	-0.117	0.921	0.238	-0.225	0.117	0.013

NORWAY AND SOUTH AFRICA

SPSS Outputs - Component loadings										
Variables	Norway					South Africa				
	TARGET factor/coordinate matrix					COMPARISON factor/coordinate matrix				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.731	-0.535	-0.045	-0.141	-0.041	0.715	0.379	0.005	-0.266	0.395
BTBM30AB	0.762	-0.500	-0.062	-0.104	-0.098	0.113	0.431	-0.430	0.574	0.141
BTBM30AC	0.761	-0.531	-0.074	-0.191	-0.138	0.974	-0.033	-0.112	-0.060	-0.046
BTBM30AD	0.720	-0.460	-0.193	-0.041	-0.151	0.775	-0.154	0.420	0.373	0.069
BTBM30AE	0.653	-0.372	0.050	0.012	-0.055	0.072	0.719	0.330	-0.063	-0.413
BTBM30BA	0.586	0.040	-0.326	0.531	-0.002	0.925	-0.086	0.068	0.002	0.014
BTBM30BB	0.712	-0.146	-0.316	0.342	0.176	0.583	0.281	0.175	-0.309	0.495
BTBM30BC	0.565	0.332	-0.448	-0.124	0.447	0.096	0.498	-0.438	0.526	0.117
BTBM30BD	0.619	0.611	-0.129	0.008	-0.027	0.789	-0.096	-0.238	-0.048	-0.388
BTBM30BE	0.633	0.533	-0.215	-0.003	0.349	0.975	-0.063	-0.100	-0.073	-0.080
BTBM30CA	0.706	-0.125	0.131	-0.052	-0.163	0.974	-0.040	-0.114	-0.060	-0.046
BTBM30CB	0.515	0.701	0.127	-0.162	-0.152	0.974	-0.045	-0.107	-0.064	-0.050
BTBM30CC	0.452	0.481	-0.007	0.258	-0.507	0.628	-0.075	0.513	0.403	-0.013
BTBM30CD	0.614	-0.457	0.346	-0.206	-0.049	-0.081	0.759	0.314	-0.143	-0.310
BTBM30CE	0.480	0.361	0.206	-0.502	0.228	0.788	-0.052	-0.237	-0.038	-0.402
BTBM30CF	0.501	0.697	0.170	-0.111	-0.109	0.974	-0.042	-0.108	-0.061	-0.049
BTBM30DA	0.459	-0.139	0.609	0.135	0.448	0.774	-0.147	0.427	0.380	0.064
BTBM30DB	0.386	-0.023	0.573	0.575	0.141	0.815	0.251	-0.058	-0.189	0.286
BTBM30DC	0.385	0.694	0.198	0.004	-0.230	0.974	-0.036	-0.109	-0.063	-0.048

Orthosim Outputs - Rotated component loadings										
Variables	Norway					South Africa				
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix					Orthogonalised Maximally Congruent Comparison Matrix: SPSS				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.731	-0.535	-0.045	-0.141	-0.041	0.770	-0.097	0.148	0.332	0.383
BTBM30AB	0.762	-0.500	-0.062	-0.104	-0.098	0.344	-0.226	-0.662	-0.314	0.158
BTBM30AC	0.760	-0.532	-0.074	-0.191	-0.138	0.860	0.456	0.114	0.075	0.054
BTBM30AD	0.721	-0.460	-0.193	-0.040	-0.151	0.715	0.186	-0.073	0.328	-0.535
BTBM30AE	0.653	-0.372	0.050	0.012	-0.055	0.331	-0.571	0.414	-0.426	-0.133
BTBM30BA	0.586	0.041	-0.326	0.531	-0.002	0.811	0.385	0.110	0.201	-0.095
BTBM30BB	0.712	-0.146	0.316	0.342	0.176	0.614	-0.156	0.196	0.508	0.302
BTBM30BC	0.565	0.332	-0.448	-0.124	0.447	0.347	-0.271	-0.617	-0.355	0.201
BTBM30BD	0.619	0.611	-0.129	0.008	-0.027	0.655	0.565	0.165	-0.257	-0.008
BTBM30BE	0.633	0.533	-0.215	-0.003	0.349	0.847	0.483	0.140	0.067	0.031
BTBM30CA	0.706	-0.125	0.130	-0.052	-0.163	0.857	0.461	0.112	0.078	0.054
BTBM30CB	0.515	0.701	0.127	-0.162	-0.152	0.855	0.463	0.119	0.080	0.048
BTBM30CC	0.452	0.481	-0.007	0.258	-0.507	0.616	0.047	-0.032	0.247	-0.618
BTBM30CD	0.614	-0.457	0.346	-0.206	-0.049	0.199	-0.669	0.415	-0.371	-0.023
BTBM30CE	0.480	0.361	0.206	-0.502	0.228	0.673	0.532	0.165	-0.285	-0.006
BTBM30CF	0.501	0.697	0.170	-0.111	-0.109	0.850	0.461	0.116	0.079	0.048
BTBM30DA	0.459	-0.139	0.609	0.135	0.448	0.718	0.178	-0.073	0.323	-0.543
BTBM30DB	0.386	-0.023	0.573	0.575	0.141	0.819	0.084	0.106	0.264	0.302
BTBM30DC	0.385	0.694	0.198	0.004	-0.230	0.859	0.457	0.117	0.077	0.052

THAILAND AND SOUTH AFRICA

SPSS Outputs - Component loadings										
Variables	Thailand					South Africa				
	TARGET factor/coordinate matrix					COMPARISON factor/coordinate matrix				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.760	-0.119	-0.183	0.392	0.075	0.715	0.379	0.005	-0.266	0.395
BTBM30AB	0.752	0.005	0.527	-0.187	-0.097	0.113	0.431	-0.430	0.574	0.141
BTBM30AC	0.757	-0.105	0.482	-0.123	-0.048	0.974	-0.033	-0.112	-0.060	-0.046
BTBM30AD	0.714	-0.023	0.489	-0.271	-0.014	0.775	-0.154	0.420	0.373	0.069
BTBM30AE	0.414	-0.396	0.013	-0.011	0.710	0.072	0.719	0.330	-0.063	-0.413
BTBM30BA	0.731	-0.033	-0.088	0.372	0.157	0.925	-0.086	0.068	0.002	0.014
BTBM30BB	0.574	0.344	-0.066	0.540	0.089	0.583	0.281	0.175	-0.309	0.495
BTBM30BC	0.143	0.794	-0.013	-0.046	0.143	0.096	0.498	-0.438	0.526	0.117
BTBM30BD	0.521	0.604	-0.009	0.247	-0.080	0.789	-0.096	-0.238	-0.048	-0.388
BTBM30BE	0.744	-0.068	-0.257	0.074	-0.272	0.975	-0.063	-0.100	-0.073	-0.080
BTBM30CA	-0.231	0.765	0.196	0.016	0.164	0.974	-0.040	-0.114	-0.060	-0.046
BTBM30CB	0.100	0.643	-0.310	-0.424	0.297	0.974	-0.045	-0.107	-0.064	-0.050
BTBM30CC	0.801	-0.040	-0.137	0.143	-0.094	0.628	-0.075	0.513	0.403	-0.013
BTBM30CD	0.018	0.893	-0.078	-0.118	-0.199	-0.081	0.759	0.314	-0.143	-0.310
BTBM30CE	0.667	-0.089	-0.353	0.215	-0.304	0.788	-0.052	-0.237	-0.038	-0.402
BTBM30CF	0.338	-0.201	-0.554	-0.453	-0.102	0.974	-0.042	-0.108	-0.061	-0.049
BTBM30DA	0.574	-0.020	-0.374	-0.430	-0.064	0.774	-0.147	0.427	0.380	0.064
BTBM30DB	0.814	-0.063	-0.138	-0.061	0.184	0.815	0.251	-0.058	-0.189	0.286
BTBM30DC	0.721	-0.050	-0.245	0.073	0.248	0.974	-0.036	-0.109	-0.063	-0.048

Orthosim Outputs - Rotated component loadings										
Variables	Thailand					South Africa				
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix					Orthogonalised Maximally Congruent Comparison Matrix: SPSS				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.760	-0.119	-0.183	0.392	0.075	0.763	0.222	0.219	0.390	0.224
BTBM30AB	0.752	0.005	0.527	-0.187	-0.097	0.129	0.530	0.515	-0.383	-0.153
BTBM30AC	0.757	-0.105	0.482	-0.123	-0.048	0.910	0.229	-0.262	0.054	-0.129
BTBM30AD	0.714	-0.023	0.489	-0.271	-0.014	0.843	-0.301	-0.047	-0.375	0.024
BTBM30AE	0.414	-0.396	0.013	-0.011	0.710	0.041	0.343	-0.119	-0.203	0.794
BTBM30BA	0.731	-0.033	-0.088	0.372	0.157	0.904	0.039	-0.212	-0.007	-0.070
BTBM30BB	0.574	0.344	-0.066	0.540	0.089	0.675	-0.010	0.258	0.442	0.269
BTBM30BC	0.143	0.794	-0.013	-0.046	0.143	0.105	0.582	0.508	-0.351	-0.096
BTBM30BD	0.521	0.604	-0.009	0.247	-0.080	0.642	0.357	-0.509	-0.076	-0.191
BTBM30BE	0.744	-0.068	-0.257	0.074	-0.272	0.904	0.213	-0.305	0.050	-0.133
BTBM30CA	-0.231	0.765	0.196	0.016	0.164	0.910	0.225	-0.262	0.056	-0.135
BTBM30CB	0.100	0.643	-0.310	-0.424	0.297	0.910	0.219	-0.269	0.055	-0.132
BTBM30CC	0.801	-0.040	-0.137	0.143	-0.094	0.701	-0.318	-0.049	-0.455	0.155
BTBM30CD	0.018	0.893	-0.078	-0.118	-0.199	-0.092	0.324	-0.019	-0.086	0.822
BTBM30CE	0.667	-0.089	-0.353	0.215	-0.304	0.640	0.388	-0.499	-0.093	-0.160
BTBM30CF	0.338	-0.201	-0.554	-0.453	-0.102	0.910	0.221	-0.266	0.054	-0.132
BTBM30DA	0.574	-0.020	-0.374	-0.430	-0.064	0.843	-0.301	-0.046	-0.384	0.033
BTBM30DB	0.814	-0.063	-0.138	-0.061	0.184	0.832	0.237	0.100	0.291	0.088
BTBM30DC	0.721	-0.050	-0.245	0.073	0.248	0.910	0.225	-0.264	0.056	-0.128

UNITED ARAB EMIRATES AND SOUTH AFRICA

SPSS Outputs - Component loadings										
Variables	United Arab Emirates					South Africa				
	TARGET factor/coordinate matrix					COMPARISON factor/coordinate matrix				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.262	0.860	0.002	0.118	0.100	0.715	0.379	0.005	-0.266	0.395
BTBM30AB	0.215	0.859	-0.050	0.125	0.076	0.113	0.431	-0.430	0.574	0.141
BTBM30AC	0.208	0.876	-0.035	0.128	-0.010	0.974	-0.033	-0.112	-0.060	-0.046
BTBM30AD	0.204	0.865	-0.028	0.093	0.089	0.775	-0.154	0.420	0.373	0.069
BTBM30AE	0.268	0.533	0.077	-0.220	-0.127	0.072	0.719	0.330	-0.063	-0.413
BTBM30BA	0.330	0.054	0.467	-0.221	-0.236	0.925	-0.086	0.068	0.002	0.014
BTBM30BB	0.379	-0.094	0.570	0.381	-0.376	0.583	0.281	0.175	-0.309	0.495
BTBM30BC	0.510	-0.178	0.247	0.545	-0.045	0.096	0.498	-0.438	0.526	0.117
BTBM30BD	0.660	-0.213	0.104	0.386	-0.165	0.789	-0.096	-0.238	-0.048	-0.388
BTBM30BE	0.699	-0.205	-0.467	0.207	0.120	0.975	-0.063	-0.100	-0.073	-0.080
BTBM30CA	0.233	-0.117	0.521	-0.134	0.677	0.974	-0.040	-0.114	-0.060	-0.046
BTBM30CB	0.422	0.005	0.497	-0.343	0.132	0.974	-0.045	-0.107	-0.064	-0.050
BTBM30CC	0.800	-0.100	-0.187	-0.245	-0.178	0.628	-0.075	0.513	0.403	-0.013
BTBM30CD	0.568	-0.205	0.400	0.267	0.355	-0.081	0.759	0.314	-0.143	-0.310
BTBM30CE	0.663	-0.151	-0.551	-0.002	0.140	0.788	-0.052	-0.237	-0.038	-0.402
BTBM30CF	0.723	-0.134	-0.256	0.073	-0.143	0.974	-0.042	-0.108	-0.061	-0.049
BTBM30DA	0.455	0.080	0.314	-0.450	-0.287	0.774	-0.147	0.427	0.380	0.064
BTBM30DB	0.756	-0.047	-0.125	-0.323	-0.150	0.815	0.251	-0.058	-0.189	0.286
BTBM30DC	0.745	-0.135	-0.190	-0.237	0.304	0.974	-0.036	-0.109	-0.063	-0.048

Orthosim Outputs - Rotated component loadings										
Variables	United Arab Emirates					South Africa				
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix					Orthogonalised Maximally Congruent Comparison Matrix: SPSS				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.262	0.860	0.002	0.118	0.100	0.720	0.111	0.491	0.223	-0.245
BTBM30AB	0.215	0.859	-0.050	0.125	0.076	0.120	0.615	-0.219	0.533	0.084
BTBM30AC	0.208	0.876	-0.035	0.128	-0.010	0.981	0.005	-0.049	-0.049	-0.035
BTBM30AD	0.204	0.865	-0.028	0.093	0.089	0.663	0.439	-0.053	-0.528	-0.177
BTBM30AE	0.268	0.533	0.077	-0.220	-0.127	0.081	0.246	0.539	-0.032	0.669
BTBM30BA	0.330	0.054	0.467	-0.221	-0.236	0.898	0.083	-0.007	-0.206	-0.112
BTBM30BB	0.379	-0.094	0.570	0.381	-0.376	0.563	0.079	0.565	0.082	-0.374
BTBM30BC	0.510	-0.178	0.247	0.545	-0.045	0.113	0.596	-0.163	0.573	0.134
BTBM30BD	0.660	-0.213	0.104	0.386	-0.165	0.830	-0.138	-0.252	-0.045	0.259
BTBM30BE	0.699	-0.205	-0.467	0.207	0.120	0.982	-0.023	-0.063	-0.080	-0.019
BTBM30CA	0.233	-0.117	0.521	-0.134	0.677	0.981	0.002	-0.053	-0.050	-0.039
BTBM30CB	0.422	0.005	0.497	-0.343	0.132	0.980	-0.002	-0.052	-0.059	-0.038
BTBM30CC	0.800	-0.100	-0.187	-0.245	-0.178	0.511	0.483	0.005	-0.572	-0.061
BTBM30CD	0.568	-0.205	0.400	0.267	0.355	-0.064	0.200	0.624	0.054	0.601
BTBM30CE	0.663	-0.151	-0.551	-0.002	0.140	0.831	-0.113	-0.233	-0.028	0.292
BTBM30CF	0.723	-0.134	-0.256	0.073	-0.143	0.981	0.001	-0.052	-0.056	-0.037
BTBM30DA	0.455	0.080	0.314	-0.450	-0.287	0.661	0.447	-0.050	-0.532	-0.169
BTBM30DB	0.756	-0.047	-0.125	-0.323	-0.150	0.821	0.092	0.311	0.164	-0.205
BTBM30DC	0.745	-0.135	-0.190	-0.237	0.304	0.981	0.002	-0.048	-0.052	-0.035

SINGAPORE AND SOUTH AFRICA

SPSS Outputs - Component loadings										
Variables	Singapore					South Africa				
	TARGET factor/coordinate matrix					COMPARISON factor/coordinate matrix				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.925	0.196	-0.006	0.019	-0.087	0.715	0.379	0.005	-0.266	0.395
BTBM30AB	0.932	0.175	0.014	0.017	-0.101	0.113	0.431	-0.430	0.574	0.141
BTBM30AC	0.943	0.188	0.017	0.007	-0.079	0.974	-0.033	-0.112	-0.060	-0.046
BTBM30AD	0.920	0.101	0.005	0.031	-0.087	0.775	-0.154	0.420	0.373	0.069
BTBM30AE	0.773	0.071	-0.021	0.015	-0.100	0.072	0.719	0.330	-0.063	-0.413
BTBM30BA	0.704	-0.089	-0.038	0.031	0.045	0.925	-0.086	0.068	0.002	0.014
BTBM30BB	-0.118	0.781	-0.305	-0.253	0.287	0.583	0.281	0.175	-0.309	0.495
BTBM30BC	-0.276	0.808	0.037	-0.229	0.155	0.096	0.498	-0.438	0.526	0.117
BTBM30BD	-0.128	0.774	-0.339	-0.349	0.057	0.789	-0.096	-0.238	-0.048	-0.388
BTBM30BE	-0.192	0.679	-0.060	-0.027	-0.212	0.975	-0.063	-0.100	-0.073	-0.080
BTBM30CA	0.750	0.084	-0.051	-0.042	0.038	0.974	-0.040	-0.114	-0.060	-0.046
BTBM30CB	0.013	0.548	0.113	0.422	0.369	0.974	-0.045	-0.107	-0.064	-0.050
BTBM30CC	-0.093	0.257	0.861	-0.135	0.007	0.628	-0.075	0.513	0.403	-0.013
BTBM30CD	-0.062	0.743	-0.002	-0.064	-0.253	-0.081	0.759	0.314	-0.143	-0.310
BTBM30CE	-0.005	0.305	0.827	-0.159	-0.147	0.788	-0.052	-0.237	-0.038	-0.402
BTBM30CF	0.102	0.251	0.158	0.571	0.608	0.974	-0.042	-0.108	-0.061	-0.049
BTBM30DA	0.770	0.108	0.054	-0.074	0.159	0.774	-0.147	0.427	0.380	0.064
BTBM30DB	-0.451	0.329	0.023	0.481	-0.359	0.815	0.251	-0.058	-0.189	0.286
BTBM30DC	-0.051	0.499	-0.166	0.536	-0.416	0.974	-0.036	-0.109	-0.063	-0.048

Orthosim Outputs - Rotated component loadings										
Variables	Singapore					South Africa				
	Orthogonalised EFA Procrustes (Row Normalized Version) Input Target Matrix					Orthogonalised Maximally Congruent Comparison Matrix: SPSS				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
BTBM30AA	0.925	0.196	-0.006	0.019	-0.087	0.925	0.196	-0.006	0.019	-0.087
BTBM30AB	0.932	0.175	0.014	0.017	-0.101	0.932	0.175	0.014	0.017	-0.101
BTBM30AC	0.943	0.188	0.017	0.007	-0.079	0.943	0.188	0.017	0.007	-0.079
BTBM30AD	0.920	0.101	0.005	0.031	-0.087	0.920	0.100	0.005	0.031	-0.087
BTBM30AE	0.773	0.071	-0.021	0.015	-0.100	0.773	0.071	-0.021	0.015	-0.100
BTBM30BA	0.704	-0.089	-0.038	0.031	0.045	0.704	-0.089	-0.038	0.031	0.045
BTBM30BB	-0.118	0.781	-0.305	-0.253	0.287	-0.118	0.781	-0.305	-0.253	0.287
BTBM30BC	-0.276	0.808	0.037	-0.229	0.155	-0.276	0.808	0.037	-0.229	0.155
BTBM30BD	-0.128	0.774	-0.339	-0.349	0.057	-0.128	0.774	-0.339	-0.349	0.057
BTBM30BE	-0.192	0.679	-0.060	-0.027	-0.212	-0.192	0.679	-0.060	-0.027	-0.212
BTBM30CA	0.750	0.084	-0.051	-0.042	0.038	0.750	0.084	-0.051	-0.042	0.038
BTBM30CB	0.013	0.548	0.113	0.422	0.369	0.013	0.548	0.113	0.422	0.369
BTBM30CC	-0.093	0.257	0.861	-0.135	0.007	-0.093	0.257	0.861	-0.135	0.007
BTBM30CD	-0.062	0.743	-0.002	-0.064	-0.253	-0.062	0.743	-0.002	-0.064	-0.253
BTBM30CE	-0.005	0.305	0.827	-0.159	-0.147	-0.005	0.305	0.827	-0.159	-0.147
BTBM30CF	0.102	0.251	0.158	0.571	0.608	0.102	0.251	0.158	0.571	0.608
BTBM30DA	0.770	0.108	0.054	-0.074	0.159	0.770	0.108	0.054	-0.074	0.159
BTBM30DB	-0.451	0.329	0.023	0.481	-0.359	-0.451	0.329	0.023	0.481	-0.359
BTBM30DC	-0.051	0.499	-0.166	0.536	-0.416	-0.051	0.499	-0.166	0.536	-0.416

CONGRUENT COEFFICIENTS

Variable ID	Saudi Arabia	Sweden	Norway	Thailand	United Arab Emirates	Singapore
BTBM30AA	0.90739	0.46484	0.63268	0.70229	0.33444	0.66366
BTBM30AB	0.45456	0.87772	0.54799	0.56741	0.82966	0.14655
BTBM30AC	0.43199	0.34063	0.40418	0.59893	0.22740	0.60526
BTBM30AD	0.45343	0.71147	0.59060	0.77922	0.51649	0.90115
BTBM30AE	0.07616	0.54947	0.66559	0.54347	0.19792	0.28828
BTBM30BA	0.94875	0.81712	0.70463	0.84893	0.60226	0.57098
BTBM30BB	0.59036	0.73686	0.79816	0.81734	0.90198	0.31278
BTBM30BC	0.90651	-0.08051	0.65254	0.66976	0.31313	0.69355
BTBM30BD	0.80741	0.99069	0.90194	0.71619	0.65453	0.29338
BTBM30BE	0.32100	0.88308	0.84872	0.93691	0.79112	0.46273
BTBM30CA	0.39500	0.48886	0.74526	-0.13420	0.20286	0.52144
BTBM30CB	0.34901	0.96419	0.85176	0.28882	0.54641	0.82998
BTBM30CC	0.74288	0.53637	0.85712	0.66331	0.63759	0.29420
BTBM30CD	0.17188	0.57486	0.83886	0.16448	0.52760	0.51591
BTBM30CE	0.66317	0.94679	0.89446	0.76871	0.90584	0.64866
BTBM30CF	0.68938	0.82981	0.86441	0.49398	0.92432	0.66359
BTBM30DA	0.79846	0.68338	0.06932	0.84621	0.80790	0.92191
BTBM30DB	0.56456	0.69739	0.67854	0.82575	0.71300	0.16325
BTBM30DC	0.63614	0.43161	0.78780	0.86041	0.86495	0.55695
Overall	0.574	0.65498	0.70182	0.62936	0.60523	0.52917