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The influence of South African teachers' qualifications and experience on the mathematics performance of learners

by

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Ethical clearance certificate

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I, Anna Sophia Robberts, student number 02626705 hereby declare that this dissertation, "*The influence of South African teachers' qualifications and experience on the mathematics performance of learners,*" is submitted in accordance with the requirements for the Magister Educationis degree at the University of Pretoria, is my own original work and has not previously been submitted to any other institution of higher learning. All sources cited or quoted in this research paper are indicated and acknowledged with a comprehensive list of references.

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A.S. Robberts

29 August 2016

Dedication

I am always aware of how blessed I am, loved by God Almighty my Creator and surrounded by my family and friends. I want to dedicate this research affectionately to all of you:

My mother and father that have always been there, loving, understanding, willing to help and my reason for trying.

My husband, for his patience, grocery shopping, neck massages and late night outings for garage chocolates when my spirit was low

My children and grandchildren, for their loving encouragement, you laughed with me, cried with me and I know you will celebrate with me

My siblings and friends that have always been positive and supportive

And to you, a person interested in the education of our biggest asset, our youth.

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Last, but not the least – my husband and children, you inspire me.

Abstract

The shocking mathematics results of South Africa's Grade 9 learners in TIMSS 2011 were received as a warning that all is not well with the country's educational system. Since good quality teaching is often associated with high performing learners, the influence of the teacher's level of education and years of teaching experience on the mathematics performance of Grade 9 learners is the focus of this study. The data originates from the South African participation in TIMSS 2011. The relative effects of these aspects on learners' performance were investigated by employing regression analysis with effect coding using the IDB Analyzer. The results suggest a positive relation between teacher education level and learner performance. The influence of years of experience on learner performance confirmed theories regarding teacher development stages and can be beneficial for professional development courses specifically aimed at teachers.

Key Terms:

Mathematics, investigation, qualifications, experience, performance, teachers, learners, learning, TIMSS.

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TO WHOM IT MAY CONCERN

This is to confirm that the dissertation titled "The influence of South African teachers' qualifications and experience on the mathematics performance of learners" was proof read and edited by me on 28 August 2016.

I verify that it is ready for publication and/or public viewing in respect of terminological correctness, language and style.

Please note that no view is expressed about the subject specific technical contents of the document.

Kind regards

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List of abbreviations

ESE	Enhancement of Emotional Capabilities
HE	Higher Education
HED	Higher Education Diploma
HSRC	Human Sciences Research Council
IDB	IEA International Database Analyzer
IEA	International Association for the Evaluation of Educational Achievement
IEA DPC	IEA Data Processing and Research Center
IQCM	International Quality Control Monitors
IRT	Item Response Theory
NQCO	National Quality Control Observers
NRC	National Research Coordinators
PDOE	Provincial Department of Education
PGCE	Postgraduate Certificate of Education
PIRLS	Progress in International Reading Literacy Study
PISA	Program for International Student Assessment
QIRC	Questionnaire Item Review Committee
SACMEQ	The Southern and Eastern African Consortium for Monitoring Educational Quality
SDA	Secondary Data Analysis
SMIRC	Science and Mathematics Item Review Committee
SPSS	Statistical Package for the Social Science
TIMSS	Trends in International Mathematics and Science Study
WEF	World Economic Forum

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Mathematical knowledge adds vigour to the mind, frees it from prejudice, credulity, and superstition. - John Arbuthnot

Chapter 1: The Problem

1 Introduction to the research

"South Africa's maths and science education has again been shown to be among the worst in the world – second last – according to the largest ever global school rankings" (BusinessTech, 2015). This is an alarming statement for the country's education sector, especially if the dire consequences of a poor level of education, particularly in subjects like mathematics and science, are taken into consideration. If one then considers the apparent lack of teacher qualifications and experience with regards to mathematics teaching, the problem is exacerbated exponentially.

Several factors could have an influence on the mathematics performance of South African learners, such as home and school resources (Visser, Juan, & Feza, 2015) and even mathematics anxiety (Mutodi & Ngirande, 2014). The teacher, as the ambassador of knowledge with his or her own background, abilities and philosophies, is one of these influencing factors. Ralph Waldo Emerson (1803 – 1882), an American essayist, philosopher and poet, already acknowledged the role that a teacher plays in the educational process in the nineteenth century by stating that a great teacher has the ability to make hard things easy ("EmersonQuotes Tillotson", 2016).

Every teacher conducts his or her class differently, whether due to the level of education or years of experience of the teacher or whether it can be attributed to the multitude of other factors that influence teaching practices. In this study the focus is on the following teacher credentials: the teacher's highest level of education completed and the years of teaching experience.

2 Background to the problem

The study of mathematics cannot be replaced by any other activity that will train and develop man's purely logical faculties to the same level of rationality. - C.O Oakley

Mathematical skills are needed in almost every aspect of life. Whether one is handling money, doing carpentry, designing fashion or preparing food for a family, every activity needs a basic knowledge of mathematics. Similarly, many undergraduate programs need mathematical skills as a basis for achievement in the subject. This argument is supported by Standslause, Maito & Ochiel (2013, p. 116) who describe mathematics as a “bridge… to science, technology and other subjects offered in any formal educational system”. Apart from the personal benefits of learning mathematics, achievement in mathematics and science serves as an important indicator of economic growth in a country because it reflects the quality of the country’s people (Wallace, 2013). Similarly, success and effectiveness in the workplace are largely influenced by knowledge of, and an ability to use, mathematics. As technology develops so rapidly, proficiency in mathematics and mathematical thinking becomes increasingly important (Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff, 2009).

The mathematics performance of learners is influenced by numerous factors. The educational system consists of several role players that each have their own characteristics that could influence the performance of learners. The school environment, for instance, has an influence regarding a learner’s concept of safety. The occurrence of bullying may for instance ultimately influence scholastic performance. Furthermore, the discipline and degree of order in the classes will also have an effect on the success of the learning experiences. The learner’s home environment (especially the availability of resources) and home language are also factors that could influence performance. Similarly, when looking at the teacher, his or her qualifications, home language, and also the relationships between the teacher and learners, are all factors that have the potential to influence academic performance (Rimm-Kaufman & Sandilos, n.d.; Rockoff 2004).

The teacher plays an important role in the education of learners (Teachers Matter: Understanding Teachers' Impact on Student Achievement, 2016). As such, there is an increasing concern that mathematics learners are being disadvantaged by teachers not fully equipped for their educational task.

3 Statement of the problem

“What is of particular concern is the performance of South Africa’s general population in mathematics and science” (BusinessTech, 2014). According to the Department of Basic Education’s (2013) academic assessments, the national average mark for mathematics in Grade 9 was 12.7% in 2012 and 13.9% in 2013, respectively. This fact should immediately alert the various stakeholders in the South African context of the magnitude of the problem. Adding to this, a report submitted by a ministerial task team, noting the quality of the National Senior Certificate (NSC), the main school-leaving certificate in South Africa, stated that “the problem lies in the classroom, and predominantly with the teacher” (BusinessTech, 2015) .

Research (Kiamanesh & Mahdavi-Hezaveh, 2008; Winheller, Hattie, & Brown, 2013) has revealed that the teacher plays a significant role in a learner’s academic achievement. Looking at performance in reading and mathematics “a teacher is estimated to have two to three times the impact of any other school factor, including services, facilities, and even leadership” (Teachers Matter: Understanding Teachers' Impact on Student Achievement, 2016). Grootenboer (2013) also emphasizes the important role of mathematics teachers in creating learners’ mathematical identities.

Teachers should "understand the mathematics they teach, how their students learn that mathematics, and how to facilitate that learning" (National Research Council, 2001, p. 10). Apart from being knowledgeable and using good teaching techniques, though, a teacher should also consider his or her role as educator in the personal and moral dimensions of the development of the learner (Grootenboer, 2013).

It is thus clear that teachers matter (Teachers Matter: Understanding Teachers' Impact on Student Achievement, 2016) and that they will, per se, influence the mathematics performance of the learners. Not only the teacher's characteristics, competence and qualifications, or even levels of self-efficacy and motivation, but also their classroom practices seem to have an influence on the performance of learners.

Seemingly, the experience and level of education of teachers have a significant influence on the performance of learners (Mogari , Kriek, Stols, & Iheanachor, 2009). The problem is that the influence of well-educated and experienced teachers on the mathematics performance of learners in South Africa is not readily known and therefore strategic initiatives cannot be implemented to ensure that these teacher credentials are taken into account in the appointment of teachers to the benefit of the leaners in South Africa.

By using the Trends in International Mathematics and Science Study (TIMSS) 2011 the influence of the teacher credentials (level of education and years of experience) on the mathematics performance of learners can be established. This could benefit the learners by informing policy on teacher education and also the appointment of teachers in schools in order to improve the quality of mathematics education. This premise has led to the research questions discussed next.

4 Research Questions

The lack of knowledge regarding the influence of teacher qualification and years of teaching experience on the mathematics performance of Grade 9 learners led to the main research question that guided this study, namely:

- How do teacher qualification and the years of teaching experience influence the mathematics achievement scores of the Grade 9 learners in South Africa who participated in the TIMSS 2011?

In order to answer the main research question, the following sub-questions should be considered:

- What does the general profile of the teachers that participated in TIMSS 2011 look like?
- What was the influence of teacher qualification and the years of teaching experience on the mathematics achievement scores of the Grade 9 learners of South Africa who participated in TIMSS 2011?
- Which of the above-mentioned teacher credentials had a significant influence on the mathematics achievement scores of the Grade 9 learners of South Africa who participated in TIMSS 2011?

5 Statement of the Hypotheses

The following hypotheses guided the study:

H_0: Higher teacher academic qualifications, specifically with mathematics or education mathematics as major area of study and also teachers with more teaching experience, do not significantly influence South African Grade 9 learners' mathematics performance as measured in the TIMSS 2011 assessments.

H_1: Higher teacher academic qualifications, specifically with mathematics or education mathematics as major area of study and also teachers with more teaching experience, do significantly influence South African Grade 9 learners' mathematics performance as measured in the TIMSS 2011 assessments.

6 Nature of the study

The study dealt with in this dissertation is an Secondary Data Analysis (SDA) project related to the TIMSS 2011 mathematics results of South African learners. Teacher questionnaires and the learner scores on the mathematics achievement tests were analysed quantitatively. Statistical techniques were used to determine the difference between the achievements of learners exposed to teachers with different levels of formal education and also to teachers with different years of experience in mathematics by using the TIMSS 2011 dataset. The expected outcome of the research was the identification of those teacher credentials that had a significant influence on the mathematics performance of South African Grade 9 learners.

Since the study used a quantitative methodology, and the findings rely on rational and deductive reasoning skills, the research is associated with a post positivist paradigm. The fact that the research is based on standardised questionnaires and performance tests, leaves room for human error. The ideal of objectivity can therefore never be fully achieved as teachers could, for example, interpret questions differently. Even in the assessment of the learners, the results are subject to widely varying circumstances. The post positivist paradigm is the most appropriate as it allows more than one reality to be accommodated.

7 Purpose of the study

The study reported in this dissertation sought to investigate the influence of teacher qualifications and experience on the mathematics performance of learners. The purpose of the investigation was an attempt to identify teacher credentials that impact positively on mathematics performance. By considering different teacher credentials and their influence on the mathematics performance scores of South African learners, those credentials that influence learner performance significantly can possibly be identified. This information could inform policy on the employment and education of teachers that could possibly improve the quality of mathematics education that may, in turn, result in a better quality life for all South African citizens. The findings of a nationwide study, such as TIMSS 2011, on different teacher credentials provide more insight into its effect and, as such, could be used to improve learner performance. Furthermore, if there is a correlation found between the qualification level of teachers and mathematic achievement, one would be in a position to reflect the need for higher qualification levels of teachers, alignment of the various training routes available, and in-service training.

The concepts listed in Table 1 are used in this study.

Table 1: Concept clarification

Learners	Persons who are scholars or are engaged in secondary school mathematics study. In this study, 'learners' typically refer to the Grade 9 cohort that participated in the TIMSS 2011 study.
Mathematics achievement	Student's knowledge and understanding of mathematics in terms of the cognitive and content domains; proficiency demonstrated by student (Mullis et al., 2009). In this study, the mathematic achievement of the learners is reflected in the marks they obtained for the various components of the TIMSS 2011 tests. The researcher assumes that the marks are a true reflection of their mathematics ability.
Statistical procedures	"A method of analyzing or representing statistical data, a procedure for calculating a statistic" (Visual Thesaurus).

8 Assumptions

The researcher assumes that:

- The 2011 data published by the IEA are accurate.
- The responses from teachers involved in the TIMSS 2011 study are accurate, reliable and honest.
- The teacher credentials identified and used in the TIMSS 2011 study are well recognised and well established teacher credentials that are intended to positively impact the academic performance of learners.

9 Delimitations

The study only focused on the performance of Grade 9 learners that participated in TIMSS 2011 and the influence of the teacher level of education and years of experience on the learners' mathematics performance. Although there are numerous teacher credentials that could influence the performance of learners in mathematics the focus was only on the level of education and years of experience of teachers that have participated in TIMSS 2011.

10 Limitations

The use of the TIMSS dataset limited the spectra of teacher qualities that could influence learner mathematics performance investigated to the ones addressed in the questionnaires. The method of data collection in TIMSS, i.e. including only questions that require the respondent to choose from the options given or only provide a numerical answer, limited in depth investigation on the level of education achieved and the teaching experience. Questions regarding the educational level and the experience of the teachers remain unanswered, especially when taking into account the teacher education reform in South Africa, particularly with regard to the interpretation of the major area of study, mathematics or education mathematics, and also concerning the grade levels and school subjects that were taught (as recorded in years of teaching experience).

11 Ethical considerations

Since the study was a secondary data analysis (SDA), full anonymity and confidentiality were ensured as only the broad findings were outlined. The ethical clearance was done internationally by the International Association for the Evaluation of Educational Achievement (IEA) and nationally by the National Research Coordinator (NRC) of South Africa. The ethical clearance process of the University of Pretoria was also adhered to.

12 Conclusion

In the light of the under-performance of learners in mathematics in South Africa, the following questions arose: which factors influence the mathematics performance of students; how do the teachers contribute to the performance of learners; how do teacher education and experience influence learner performance? These questions are amongst those that are investigated in Chapter 2.

Chapter 2: Review of Literature

1 Introduction

This chapter starts off with a discussion on the importance of the subject mathematics and the most common goals associated with the learning of mathematics. The factors that influence mathematics performance are considered by categorising them as school and school related, learner and learner related and teacher and teacher related. Thereafter, teacher credentials (qualifications and experience) and its influence on the mathematics performance of learners will be discussed critically.

2 The importance of mathematics

Mathematics is a crucial skill that promotes learner preparedness to succeed in further studies, in his or her daily life and in the workplace (Mullis et al., 2009). “It [mathematics] is at the heart of everyday technology from our smartphones and tablets to the increased automation in daily tasks from driving to shopping” (Hodgen & Marks, 2013, p. 3).

Ali (2013) stated that mathematics develops a learner’s thinking skills and promotes logical reasoning. “Mathematical literacy in the context of higher education (HE) is essential if students are to achieve their full potential” (Tariq, Qualter, Roberts, Appleby, & Barnes, 2013, p. 1144). They furthermore stated that mathematics develops, amongst other skills, the learners’ ability to cope with stress and negative emotions. Mathematics is a core subject to a good all-round education (Mathematics is important, 2013) and as such should be a fundamental part of a learner's school career. Similarly, success and effectiveness in the workplace are largely influenced by knowledge of and an ability to use mathematics (Hodgen & Marks, 2013). Mullis et al. (2009) furthermore states that as technology develops at an alarming rate, proficiency in mathematics and mathematical thinking becomes increasingly important.

In the South African context, these statements raise alarm. According to the World Economic Forum (WEF), South Africa ranks 146th out of 148 countries when considering the quality of mathematics and science education (Schwab, 2014). Even though this assessment was not based on standardised tests but derived from interviews with "business leaders", results published after participation in various assessments confirmed that South Africa is facing numerous educational challenges. The Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) assessed Grade 6 pupils across 15 countries and found that South African learners' mathematics performance was worse than those of learners in Mauritius, Kenya, Tanzania, Seychelles, Swaziland, Botswana and Zimbabwe, placing South Africa in eighth place (Spaull, 2011). Furthermore, after the TIMSS assessment in 2011, Reddy (2012a), executive director and principal investigator of TIMSS at the Human Sciences Research Council (HSRC) pointed out that the best performing South African learners draw near to the mean performance of the top performing countries. This is even more disturbing when taking into account that in South Africa (as in Botswana and Honduras), Grade 9 learners participated in the TIMSS assessment and not Grade 8 learners as in the rest of the world. Apparently, as stated by Spaull and Kotze (2014, p.8), this is due to the fact that "the international Grade 8 test was too difficult for South African students, and consequently too many students were performing at guessing level on the multiple choice questions (i.e. no better than random)".

The matric (final school year examination) results of learners in South Africa do not reflect the reality surrounding the educational system. Even though 78.2% of learners passed the 2013 matric exams, only 562 112 out of the 1 261 827 learners who started Grade 1, in 2002, were still in the education system to write these matric exams (Wilkinson, 2013). Apart from the learners that were left behind, Wilkinson (2013) continued that the remaining learners tend to choose easier subjects (mathematical literacy instead of mathematics), and subsequently more learners will pass. When we focus specifically on the subject mathematics, the achievement of an average of 13.9% for mathematics in Grade 9 (Department of National Education, 2013) and also the fact that only 35.1% of learners in South Africa achieved 40% and more for mathematics in the November 2014 Examination (Department of Basic Education, 2014) advocates for urgent measures by stakeholders. Howie (2003) noted that South Africa's multicultural society of 43 million people pose a special challenge regarding the offering of quality mathematics education. The matric results of South African learners, especially in mathematics, confirms Spaull's (2013, p 3) conclusion that "there is an ongoing crisis in South African education, and that the current system is failing the majority of South Africa's youth".

3 Most common goals associated with the learning of mathematics

The NRC states that the goal of the learning of mathematics is to educate learners to be "mathematically proficient" (Kilpatrick, Swafford, & Findell, 2001). Mathematical proficiency according to the NRC entails conceptual understanding (understanding of mathematical concepts, operations and relations), procedural fluency (ability to carry out procedures efficiently), strategic competence (skillful in the formulation, representation and solving of mathematical problems), adaptive reasoning (ability to think logically, reflect on, explain and justify answers) and "productive disposition" (attitude towards mathematics being a sensible, useful and worthwhile subject, and a belief in thoroughness and one's own talent) (Kilpatrick et al., 2001).

Another term often used for the outcome of mathematical learning is "mathematical literacy". According to the Program for International Student Assessment (PISA), "mathematical literacy" refers to a learner's ability to analyse, reason and communicate effectively while solving mathematical problems in different contexts (OECD, 2004). A strong relationship is found in the categorisation of the different cognitive activities between NRC and PISA: The five strands of thinking skills (according to the NRC) is described by PISA as reproduction, connection and reflection and includes "thinking and reasoning; argumentation; communication; modelling; problem posing and solving; representation; and using symbolic, formal and technical language and operations" (OECD, 2004, p. 40).

Apart from the difference in describing the cognitive abilities necessary to be proficient/literate, the content of mathematics is also described in different terms. The NRC states that "mathematics" includes many different subject areas e.g. number and operations, measurement, geometry, descriptive statistics, probability and algebra (Kilpatrick et al., 2001). PISA specifies four content areas: (i) space and shape, (ii) change and relationships, (iii) quantity and (iv) uncertainty (OECD, 2004). Mathematical achievement is also measured in numerous ways. TIMSS measures mathematical achievement on cognitive (knowing, applying and reasoning) and subject (Algebra, Geometry, Data and Chance and Number) domain (Mullis et al., 2009).

One can conclude by considering the above-mentioned viewpoints that the overarching goal of learning mathematics should be to produce students with an ability to think critically and creatively by using their mathematical knowledge in real life situations. Therefore, the performance of learners in mathematics can not only be considered on content/subject domain, but the cognitive development of the learner should also be taken into account.

4 Factors that influence mathematics performance

Multiple studies (Bayaga & Wadesango, 2014; Kotzé & Strauss, 2007; Sabah & Hammouri, 2010; Tariq et al. 2013; Winheller et al., 2013) have been conducted regarding factors that may influence learner performance. These include: the effect of gender and social background (Kotzé & Strauss, 2007), students' attitude (Bayaga & Wadesango, 2014), the role of emotional intelligence (Tariq et al., 2013), student's confidence (Parsons, Croft, & Harrison, 2009), self-perception (Shen & Tam, 2008), language and other background factors (Howie, 2003), the impact of instructional practices and resources (Sabah & Hammouri, 2010) and many more factors that have been reported on. Bayaga and Wadesango (2014, p. 50) stated (in a study on the factors that influence mathematics performance) that

> "The findings are important for the South African educational system since changing self-concept and attitude of students towards mathematics and improving the teaching procedures in the classroom are much easier to achieve than changing background factors affecting students' performance".

The factors that may influence a learner's performance can be grouped in three categories: school and school related, teacher and teacher related and learner and learner related factors (Shavelson, McDonnell, & Oakes, 1989). Each category also entails factors regarding the physical, personal and emotional dimensions of the participants and is as such complex divisions of a bigger entity.

4.1 School and school related factors

Schools are "social organizations with defined rules and procedures that determine the degree of activities and behaviour of each member" (Mbithi as cited in Standslause et al., 2013, p. 116). Studies on effective teaching (Kiamanesh & Mahdavi-Hezaveh, 2008; Winheller et al., 2013) have found that a positive learning environment and school engagement can result in higher morale and better student performance. "School quality is a multi-faceted concept which goes beyond transmission of knowledge or development of learning skills to include structure, teaching, curricula, affect and social environments" (Winheller et al., 2013, p. 2).

According to the executive summary provided by the IEA on the TIMSS 2011 data, "school resources (materials, supplies, heating/cooling/lighting, buildings, space, and staff) as well as resources specifically targeted to support mathematics instruction (specialized teachers, computers, computer software, calculators, library materials, and audio-visual resources)" or the lack thereof, have an influence on learner achievement worldwide (Mullis, Martin, Foy, & Arora, 2012). Learners need to experience a safe learning environment (Sharma, 2015) without concerns about safety and behaviour problems like bullying (Juvonen & Graham, 2014), to maximise achievement. The highest mathematics achievement is obtained in schools with motivated learners, effective teachers (Stronge, 2013), clear curricular goals and parental involvement (Jeynes, 2007).

4.2 Learner and learner related factors

Learner related factors could roughly be categorized in background factors (parent and environment related), personality characteristics (self-efficacy, confidence, attitude towards mathematics, emotional intelligence and more) and cultural factors (ethnical and therefore also gender differences and language).

Learner background factors that influence mathematics performance concern the immediate environment in which the learner operates e.g. the parent's/caretaker's educational level and occupation and home resources (including books, basic nutrition and care) (Mullis et al., 2012). Parent involvement in the early years of childhood could also influence mathematics achievement of learners (Jeynes, 2007). In the executive summary provided by the IEA on the TIMSS 2011 data, it is stated that learners who engaged in early numerical and literacy activities in preschool years, proved to have higher achievement in mathematics (Mullis et al., 2012).

The learner's personality characteristics are believed to influence mathematics performance as well. Learner and learner related factors e.g. emotional intelligence, self-efficacy, attitude towards mathematics, confidence, even home language are widely discussed in literature (Howie, 2003; Parsons et al.,2009; Ma & Kishor, 1997; Tariq et al., 2013; Warwick, 2008; Winheller et al., 2013; Zimmerman, 2000).

Mathematics test performance is also affected by stress and negative emotions. Fortunately, the usual negative effect on performance can be refuted by the enhancement of emotional capabilities (ESE) (Tariq et al., 2013). An individual can learn to understand and regulate emotions that could hinder learning strategies and motivation to stay focused on academic tasks (Tariq et al., 2013). Even self-efficacy beliefs, an individual's judgement on their own capabilities and performance (Bandura as cited in Parsons et al., 2009) have an influence on the learner's willingness to participate in challenging tasks that will promote learning (Peters & Kortecamp, 2010). A learner's self-efficacy beliefs are informed not only by their performance in mathematics in comparison with others, but are also influenced by classmates, peers and teachers. Research (Parsons et al., 2009; Warwick, 2008; Winheller et al., 2013; Zimmerman, 2000) has shown that a learner's self-efficacy beliefs have an influence on mathematics achievement.

Winheller et al. (2013) found that apart from a learner's self-efficacy beliefs, a learner's attitude ("liking a subject") and also the quality of learning perceptions (including the learning environment) play a role in the mathematics performance of a learner. A learner's attitude towards mathematics is influenced by the feedback (from teachers and peers) that they receive (Winheller et al., 2013). In a summary of the results, published after the TIMSS 2011 assessment, it was stated that learner attitude and mathematics performance are positively related (Mullis et al., 2012). They concluded that learners who reported that they "enjoy learning mathematics", feel confident in their mathematics ability and appreciate the value of mathematics, and had the highest mathematics achievement. Parsons et al. (2009) confirmed this statement and defined three types of confidence: overall confidence in mathematics, topic confidence and application confidence. Similarly, Rai, Beck and Arroyo (2013) found that confidence and frustration have an influence on learner achievement and that apart from attending to learners' cognitive skills, the motivational and affective aspects of learning should also receive attention.

Cultural factors, e.g. ethnical and gender differences as well as a learner's home language have an influence on mathematical performance (Howie, 2003). Howie

(2003) reported that 70% of South African students write the mathematics tests in their second or even third language, adding to the complexity of teaching in South African context.

Considered together, background and cultural factors are a part of a learner's experience, inevitably influencing their performance. The learner personality characteristics (regulation of emotions, self-efficacy beliefs, quality of learning perceptions, confidence, attitude towards mathematics) can however be influenced by an effective teacher with sound teaching strategies (Akey, 2006).

4.3 Teacher and teacher related factors

The process of teaching middle school learners proves to be challenging as the learners are in the middle of the development of their own identities (Ladd & Sorensen, 2015). This critical stage, associated with intensified social pressures from their friends and where parents are less involved, serves as a turning point for many learners and a positive teacher's influence is priceless (Ladd & Sorensen, 2015).

In an article published by Rand Corporation (Teachers Matter: Understanding Teachers' Impact on Student Achievement, 2012) it is stated that the effect of a teacher is approximately two to three times that of any of the other school factors. Grootenboer (2013) also emphasised the teachers' influence on the development of the learner's mathematical identity, that will, per se, influence mathematics achievement and as such the futures of the learners. It thus seems that teachers matter; a teacher "moulds the most precious material of the land, viz., the boys and the girls in their most impressionable period of development in the required shapes." (Agnihotri, 2013, p. 1).

The article “Learning for tomorrow's world: first results from Pisa 2003” (OECD, 2004), points out that a teacher’s behaviour and interaction with learners have an even greater impact on learner achievement, than the content of a lesson. Creemers (2002, p. 21) accentuates this fact by stating that at “the classroom level, teacher behaviour is central”. The teacher has to create an environment in which learners feel safe to discover, to enquire and to share and support each other (Graves, et al., 2009; Grossman, Hammerness, & McDonald, 2009). This sentiment is supported by Anderson, Hamilton and Hattie (2004) who found that the classroom climate, a product of the teacher’s interaction with learners, influences a learner’s self-efficacy and performance.

The teachers are also individuals with unique personal characteristics, with their own background and culture influences. Teacher behaviour and attitude are shaped by numerous factors such as self-efficacy (Bandura, 1977), self-confidence and motivation (Ololube, 2006). As role models, teachers’ attitudes towards teaching and learners could play a detrimental role in their job performance if they do not experience job satisfaction (Grootenboer, 2013). When teachers do experience job satisfaction, it is likely to have a positive effect on their job performance since they are motivated to teach, are focused on learner outcomes, and are able to create stability in the learning environment (Agnihotri, 2013; Bishay, 1996; Klassen & Chiu, 2010; Michaelowa & Wittmann, n.d.; Ololube, 2006). Agnihotri (2013, p. 2) concludes that

> “it is vital to see that the teachers are content in their professions because the good teacher motivates, adopts curricular provisions to individual needs; adjusts teaching techniques to specific situations, manages the classroom methodically and expeditiously; assumes and conducts efficiently his administrative and extra class responsibilities; and cooperates cheerfully and intelligently with parents and community agencies”

Since the teacher needs to prepare learners for the 21st century, they should not only have extensive content and curriculum knowledge but should also be well-informed regarding pedagogy and be confident in using information technology.

Furthermore, they should also understand the learners and know their characteristics (Darling-Hammond, 2006; Hill & Lubienski, 2007). Grossman, Hammerness and McDonald (2009) extends this list of qualities necessary to teach even further by adding that a teacher should understand how learning takes place, should be able to identify problem areas in the learning environment and should be able to do proper assessment of the learning gains.

Ololube (2006) summarised a selection of elements necessary for educational success and performance, namely the professional knowledge and skills of the teachers, educational resources and also the strategies they employed to maximise learning gains. These elements gave rise to the conceptual framework used for the purpose of this study.

5 Conceptual framework

TIMSS 2011 data were collected in school context relating to different components: learner and teacher background, the schooling process (school environment and curriculum) and learner achievement in the mathematics tests. These components form part of any educational system. To comprehend the range of this study, a conceptual framework that combined an educational system and the above-mentioned components was developed.

The important components of an educational system, according to Shavelson, McDonnell and Oakes (1989), are inputs (characteristics of students and communities, financial and human resources and other educational inputs) as well as processes (reflecting the adequacy of the curriculum and instruction and the nature of the school) and outputs (learner achievement, participation and the attitudes and aspirations of learners). The components of an educational system as proposed by Shavelson et al. (1989) are illustrated in Figure 1.

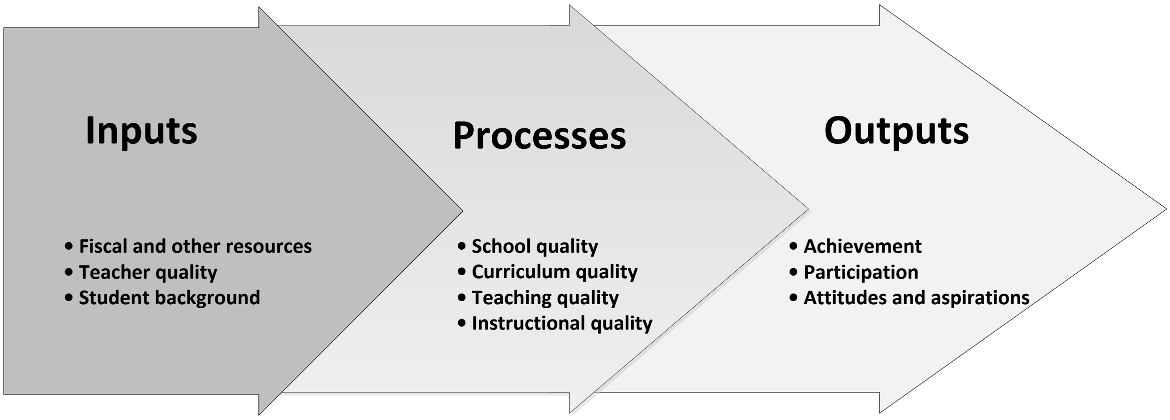


Figure 1: Educational system developed by Shavelson et al. (1989)

The study focused on the influence that teacher level of education and years of experience had on the mathematics performance of learners. The conceptual framework developed by Shavelson et al. (1989) and adapted by Howie (2003), was customised for this study. The inputs referred to information regarding the credentials of teachers, with a specific focus on their level of education (that ranged between obtaining matric as the lowest level and an honours degree as the highest level) and years of experience. The influence of the years of experience was investigated by using developmental models as proposed by Katz, Huberman and Day. Processes referred to everything that happened in the schooling system: the subjects, curriculum, teaching approaches and the learning opportunities that could have an influence on the learners' performance. The mathematics performance of the Grade 9 learners that participated in TIMSS 2011 was regarded as the outputs of the educational system. The presentation of the educational process in terms of "inputs", "processes" and "outputs" were used as a conceptual framework for the study, as illustrated in Figure 2.

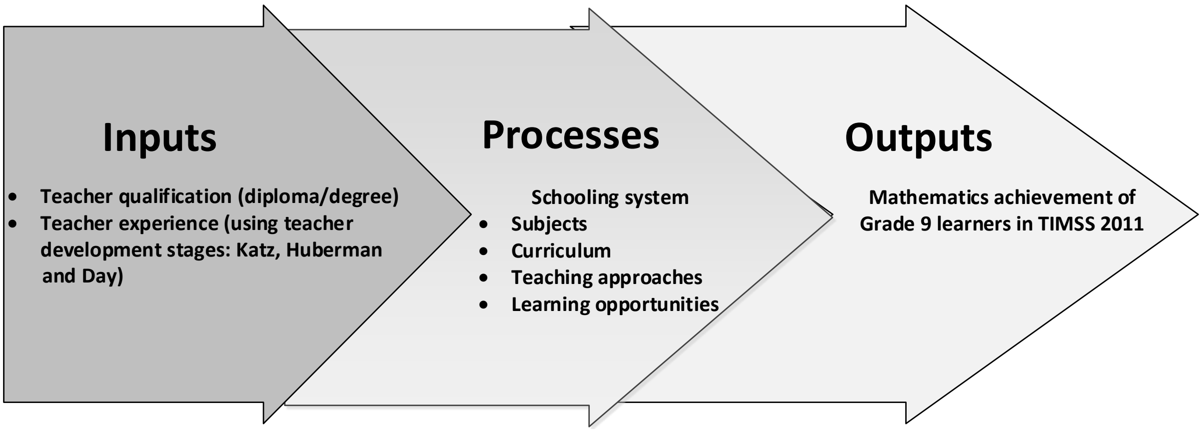


Figure 2: Conceptual framework

For the purpose of this study, the focus will fall on teacher qualifications and experience as an indication of their professional knowledge and then on the educational success and performance of Grade 9 learners in terms of mathematics.

6 Teacher qualifications and teaching experience

Good teachers, according to Hanushek (2002) get large gains in learner achievement, one and a half grade-level equivalents, versus only a half year of gains for a single academic year by a bad teacher. Thus, learners subjected to a good teacher can gain a full year's learning growth. There is little consensus regarding the connection between teacher credentials, for instance highest educational level and years of experience, and learner performance (Goldhaber & Brewer, 1996). Some of the teacher attributes, such as enthusiasm and talent to teach, that play an important role in teaching a class are not measurable (Goldhaber & Brewer, 1996). A teacher's quality is in part measured by the performance of his or her learners.

6.1 Teacher qualifications

Ololube (2006) argues that educational success and performance are determined by the professional knowledge and skills of teachers. Teachers' academic degrees are the topic of numerous studies and, interestingly, the findings seem to be inconclusive. Darling-Hammond (2006) believes that student success is not necessarily dependent on the educational level of the teacher, for example, the likelihood of successfully completing a Master's degree. Hanushek and Rivkin (2006) similarly found little, or no, evidence that the quality of teaching was raised by obtaining a master's degree. Conversely, numerous researchers (Rice, 2003; Goldhaber & Brewer, 2006; Rosenthal, 2007) have found that when teachers have earned an advanced degree in their subject area, it has a positive influence on their students' performance. Could it be that a teacher that engages in further study is more committed to the profession? The relationship, if any, between the level of education of teachers and learner achievement, being a mystery, need to be further researched.

In the South African context, teacher education has been subjected to numerous changes. At first, as a result of the 1910 Constitution, white teacher training was placed under the jurisdiction of South Africa's four provinces (Sayed, 2015). Separate teacher education colleges, where coloureds, Indians and black people could obtain teacher qualifications were administered by various "separate development" political structures (Gordon, 2009). The results were that 18 education departments were responsible for teacher training, 105 colleges distributed throughout the country where teachers were trained and 32 universities and Technicons (Sayed, 2015). Since curricula and examinations were controlled by various stakeholders, the quality of the education of teachers that obtained their qualifications at different colleges fluctuated. (Gordon, 2009). Gordon (2009, p. 14) also stated that "many teacher education colleges for African student teachers operated essentially as secondary schools rather than as tertiary institutions".

South Africa encountered an era of constitutional and institutional changes since 1994. Two key policy changes in teacher education influenced the existing systems. Teacher education has been nationalised into one teacher education system for the country. In this way uniform norms and standards have been assured and quality teacher education has been secured (Sayed, 2015). The other policy changes concerned the level of the curriculum, the types of qualification, the system of accreditation and also the norms set out for educators (Sayed, 2015). Consequently, teacher education colleges were incorporated into universities (Kruss, 2007). Mergers and partial incorporations restructured the education playfield even further. All of these institutional changes gave rise to new policy frameworks, a change in curricula and consequently to the restructured qualifications that teachers received. The professional development of teachers was essential as a result of these acute institutional changes and the resulting organisational instability (Kruss, 2007).

Previously, teacher education was obtainable at teacher colleges and at universities. The South African Government Gazette No. 29832 of 2007 outlined two available teacher training options, regardless of specialisation. A teacher could either obtain a bachelor’s degree in education (480 credits) or a bachelor’s degree in an appropriate subject (360 credits) followed by a one-year advanced diploma program in education (120 credits) (Department of Education, 2007).

The curriculum taught in teacher training also changed to be in line with the school curriculum change to an outcomes-based system. The approach moved to be learner-centered with the emphasis being on learning areas and not on individual subjects as in the previous curriculum (Sayed, 2015). The implications of these changes were far reaching: apart from training new teachers to be proficient in applying the outcomes-based curriculum, teachers that were trained under the previous system needed in-service support (Sayed, 2015).

The many challenges faced by the educational system in South Africa, even though addressed with great vigour did not translate into learner performance. As stated by Gordon (2009, p. 44): “Teacher education is central to changing this situation, and to creating an education system that meets the country’s needs”.

6.2 Teaching experience

Teaching experience is another teacher credential frequently discussed in literature (Zhang, 2008; Rice, 2010). Apart from the influence on the performance of learners, Ladd and Sorenson (2015) remarked that experienced teachers also contribute to the improvement of learner behaviour especially with regards to learner absenteeism. They furthermore pointed out that teachers with experience can influence the behavioural as well as the cognitive development of learners. Besides the influence on the learners, experienced teachers also influence the school environment by providing stability and acting as mentors for their younger colleagues (Rosenthal, 2007).

A teacher learns to teach by experience and, since this learning occurs in a broader framework that includes a teacher's personal and professional development, it may influence the performance of his or her learners either positively or negatively (Day, 1999). Numerous studies suggest that the first few years of teaching experience has the biggest influence on learner performance. Gorman (2005) acknowledges the fact that first year teachers have lower learner performance scores than other teachers but concludes that teachers' influence on learner performance improves until their fourth year of teaching. Similarly, Kane, Rockoff and Staiger (2007) found that teachers develop fast in the first three years of teaching but their experience-related influence on learner performance thereafter is trivial. Rice (2010) supplements these statements by stating that teachers' efficiency tends to decline after their first few years of teaching. In contrast, Rockoff (2004) established that teachers with more than ten years of experience have a positive influence on learner performance and Ladd and Sorenson (2015) found that teachers improve and develop continually in their careers.

There are a variety of models described in literature regarding the developmental stages of teachers (Katz, 1972; Dreyfus, 2004; Benner et al., 2009; Day, 2012). Fuller (as cited in Conway&Clark, 2003) distinguished six "concerns-based" developmental stages where the focus moves from concerns regarding to the teacher's own abilities, to concerns regarding the teacher's contribution to pupil change. According to Katz (1972) however, teachers experience four developmental stages: a survival stage in their first year of teaching - "Will I be able to get through the day?" In the second stage, called consolidation, teachers start to focus on individual problem children asking questions such as "How can I help….?" During the third or fourth year of teaching, (the next stage, "renewal"), teachers are receptive to new innovative ideas to implement in their classrooms. Maturity may be reached within three to five years when teachers have come to terms with themselves and search insight, perspective and realism.

The teacher development model proposed by Dreyfus (2004) identifies five levels of skills development. The teacher moves from being a "Novice", to an "Advanced beginner" where after the "Competent", "Proficient" and "Expert" teacher evolves. Benner et al. (2009) adopted this model to use in the medical profession in the training of nurses. Katz (1972), Dreyfus (2004) and Benner et al. (2009) described teacher development as a process that is completed within approximately five years. The question arises whether a teacher with five years of experience can be deemed just as effective as a teacher with 20 years of experience? For this reason, more comprehensive development stages models were investigated.

Huberman (as described in Joerger, 2010) and Day (2012) also denoted models for the developmental stages of teachers, similar to the previously mentioned models but with the focus also on the later stages in the teacher's life cycle. The first three stages in Huberman's and Day's models are quite similar; the names of the stages and the years included in each stage only differ slightly. The only significant difference is in the stages proposed for teachers that have more than 15 years of experience. Day (2012) has divided the years as 16-23 and then 24-30 and 31+ whereas Huberman (as described in Joerger, 2010) only has two stages, namely 19-30 and 31+.

Teacher self-efficacy beliefs, according to Klassen and Chiu (2010), grow from the first to the 23rd year of teaching experience, where after it gradually declines. Furthermore, they found the same tendency in teachers' confidence levels regarding their teaching skills, an increase up to the mid-career years and then a decline as teachers approach the end of their careers. Teachers learn from experience how to teach (Day, 1999). Day continues by stating that being an experienced teacher however, does not mean that the teacher can necessarily be seen as an expert. An expert, according to Sternberg and Horvath (1995), has more cohesive comprehension, formation structures and knowledge of social and political circumstances in which teaching occurs. Experts are efficient and show insight as they can apply information gained in other circumstances to the problems they are facing (Sternberg & Horvath, 1995).

The numerous findings regarding the influence of teaching experience on the performance of learners, as discussed in this section, may seem contradictory. A possible explanation may be that there is a multitude of interdependent factors that could have an influence on the performance of learners and that the influence of teaching experience cannot be solely rated in terms of performance.

7 Concluding remarks

In this chapter the importance of the subject mathematics was investigated and also how studying mathematics is defined by different stake holders. The factors that could influence the mathematics performance of learners, school and school related, learner and learner related and then teacher and teacher related were discussed. Teacher credentials, qualification and years of experience also received attention. The next chapter gives an outline of the research design and methodology followed in this research.

Chapter 3: Research Design and Methodology

1 Introduction

The research reported in this dissertation focused on the influence of the teacher's highest level of education and years of teaching experience on Grade 9 learners' performance in mathematics.

At the outset of this chapter, the philosophical foundations guiding the research are outlined. The research paradigm, the research design and the methods selected to address the research questions are discussed. Furthermore, attention is given to data types, the sampling procedures followed, the instruments used to collect the data and the data collection procedure. Additionally, this chapter deals with data access, the statistical tests performed in the data analysis process, the validity and reliability as well as the ethical considerations surrounding the research.

The data gathered by TIMSS 2011 of South African Grade 9 learners was used to conduct the research. As such, after the discussion of the philosophical foundations of the research, this chapter reflected on the procedures followed by TIMSS 2011 and thereafter focused on issues applicable to this specific research project.

2 Research paradigm

Central to the entire discipline of educational research is the choice of a suitable research paradigm. A paradigm is "a set of assumptions or beliefs about fundamental aspects of reality which gives rise to a particular world-view" (Maree, 2007, p 47). The research paradigm provides the lens through which the phenomenon is studied, it delineates the intent of the research, the motivation and expected outcomes (Mackenzie & Knipe, 2006). The philosophy of the nature of reality (ontology), how it can be discovered (epistemology) and the practices used to study a phenomenon (methodology) are interdependent and form a coherent research paradigm. The research problem also needs consideration, as it will influence the approach that is followed in the investigation (Krauss, 2005).

There are two basic approaches distinguished in research: the scientific method (being objective, positivist) and the emerging worldview (being subjective, interpretivist). The scientific method evolved from Aristotle's idea of measurement and observation, to Bacon's idea of observations, stating hypotheses, conducting experiments and finally testing the hypotheses (Edmund, 2016). Over the years the idea of the scientific method changed as different disciplines started to develop their own methodology and terminology. Where the scientific method was at first only typified as being positivistic and rationalist (Maree, 2007), knowledge being a concrete reality that can be discovered through sense observation and measurement (Holden & Lynch, 2014) the focus had gradually moved to include a post-positivist approach. Originally, the goal of science was merely to develop an understanding of the world through scientific means, in order to control it and make predictions based on the laws of cause and effect (Maree, 2007). In due course the post-positivist approach accepted that uncovering the truth is an admirable, but not an achievable goal because of the fact that all scientists have their own cultural experiences and worldviews that influence the uncovered truth (Trochim, 2006a). In other words, the researcher's human limitations cause an imperfect discovery of "reality". In a positivistic approach research always begins with a theory that is tested by the collected data, after which it is revised (Creswell, 2003). Khun (1962) however stated that theories merely outline the truth and that any theory can be challenged by new understandings. The post–positivist approach moved the focus from absolute certainty to probability (Chilisa & Kawulich, 2012), where reality can never be perfectly understood (Maree, 2007). In a post–positivist approach the fact that all observations are fallible and subject to human error is taken into consideration (Trochim, 2006a).

The ontological assumption of this research (an assumption about the "nature and form of reality" (Nieuwenhuis in Maree, 2007, p.53)) typified the post-positivist paradigm. The influence of specific teacher credentials (with highest level of education and years of teaching experience as independent variables) on the mathematics performance of learners (dependent variable) was investigated quantitatively by applying statistical tests. This was done in order to promote the claim that the specific teacher credentials could indeed, within a certain level of probability, influence a learner's mathematics performance.

The epistemological assumption, an assumption regarding the "method for knowing the nature of reality" (Nieuwenhuis in Maree, 2007, p.55) of the post-positivist paradigm was also evident in this research. The researcher and the participants of the study were never in direct contact so that the researcher's theories, hypotheses and background knowledge could not in any way influence the observations or data collection process. Furthermore, since secondary data were used, the following statements confirmed the fact that knowledge arose from reasoning (rationalistic theory) and not from experience (empiricist theory): The topic (performance in mathematics) and methodology (quantitative interpretation) were related to objective, and not subjective, criteria. The categories to be tested had to be specified before the research process started (as is the case with the TIMSS data set) and could not emerge over time. Hypotheses could be developed (before using the TIMSS data set) and then tested and justified by using statistical methods. The hypotheses could just confirm the probability of the influence of different factors, although numerous other factors could also have had an influence on the performance of learners. The problem identified can be reduced to different elements (looking at variables and combinations of variables that might have had an influence) and as such could be better understood. The findings of the research relied on rational and deductive reasoning skills, focusing on discovering different dimensions regarding the teaching credentials that could possibly have an influence on the performance of learners in mathematics.

A post-positivist approach to methodology was followed. The variables were summarized into numerical scales to be analysed quantitatively. The researcher acknowledged the limitations of the fixed responses on the questionnaires. No constructed responses were available to provide more information regarding the educational level, where and when the teacher graduated and also concerning the years of experience. Since the responses on the statements could not be investigated further (limitation of data set) and is therefore subject to human error and misunderstanding, the outcome cannot be absolutely representative of the truth and as such, a post-positivist approach will suffice.

In the light of the above-mentioned it is evident that the research question, the data used to assist in obtaining a possible answer and the method followed to analyse the data, were best supported by a post-positivist approach. The limitations, as stated in the previous paragraph, confirmed the post-positivist stance of the fallibility of observations and that the results can only confirm a probability and is not necessarily the absolute truth.

3 Research design

Research designs can be categorised as being either experimental, quasi-experimental or non-experimental (Trochim, 2006d). According to Creswell (1994), the distinction between experimental designs and non-experimental designs lies in the fact that the former usually consists of a pre-test (administered to the experimental and control group), a specific treatment (addressed to the experimental group) and finally a post-test (administered to the experimental and control group). The research conducted for the purpose of this study was classified as non-experimental since no treatment and also no control group existed.

The classification of non-experimental designs can be either based on the purpose of the research or of the time frame in which the research took place (Johnson, 2001). For the purpose of this research, a cross-sectional research design was followed where the data was collected globally in 2011 enabling the researcher to make comparisons between participants subjected to different factors (Belli, 2008).

The research design also includes the process followed in the conduction of the research. According to Kumar (2011) two basic approaches to enquiry exists: the structured and the unstructured approach. A summary of the two approaches (Kumar, 2011) can be found in Table 2.

Table 2: Structured and unstructured approaches to research

Approach	Purpose of enquiry	Process	Use of findings
Structured	Determine the extent of a problem, issue or phenomenon.	The objectives, design, sample and the questions that is asked, is predetermined.	Policy formulation
Unstructured	Explore the nature, variation or diversity in a phenomenon, issue, problem, and attitude towards an issue.	There is flexibility in all these aspects of the process	Process understanding

Kumar (2011) further states that a structured approach to enquiry can be categorised as quantitative research and the unstructured approach to enquiry as qualitative research. In a qualitative approach, the nature of the enquiry is value-laden, looking into the life experiences and the process of assigning meaning to the world whereas measurement and analysis of contributory links between variables are accentuated in a quantitative approach (Denzin & Lincoln, 2000). The quantitative approach explains the "if" whereas the qualitative approach focuses on the "how" and "why" (Terrell, 2012).

The choice of an appropriate research methodology depends on the decision regarding the type of information/data to be gathered and the time frame in which it should be done (Taber, 2012). According to Creswell (2003) a research problem that focuses on the identification of factors influencing a process/result or that uses an intervention to change behavior is best researched by using a quantitative approach. He furthermore states that a quantitative approach is particularly useful to verify theories or explanations, identify variables (the best predictors of outcomes) to a study and relate variables in hypotheses or questions. He continues that the quantitative approach is useful to observe and measure information numerical, use unbiased approaches and to employ statistical procedures (Creswell, 2003).

After considering the above-mentioned statements and looking at the data (collected by the questionnaires and performance tests of TIMSS 2011) and research questions to be addressed, the quantitative approach was deemed most appropriate for this research study. The data collected were exact and since there were no open-ended questions, it was not open to interpretation. The teachers however could have interpreted the questions differently and they did not have the opportunity to elaborate on the institution where they have studied or the kind of experience that they have. These elements were acknowledged as a few of the limitations of this research project. Since the questionnaires did not accommodate extended answers where teachers could provide more information regarding their qualifications and experience, the data cannot provide insight as to “why” certain teacher credentials did not affect learner mathematics performance. The only valid deduction is: “if” teachers have certain teacher credentials; it has a positive or negative influence on the learner performance. Therefore, a quantitative approach was appropriate. This was consistent with Terrell’s qualification of research depending on the answers to the questions “if” and not “what” or “why” (Terrell, 2012). In line with Creswell’s (2003) definition, statistical procedures were employed to analyse the data in order to identify the influence of specific variables on the performance of learners. As such, a quantitative approach was followed in the research.

4 Secondary data analysis

The research was a Secondary Data Analysis (SDA) project related to the TIMSS 2011 mathematics results for South African learners. Teacher background questionnaires and learner achievement scores in mathematics were analysed quantitatively, employing categorical statistical techniques to evaluate the influence of different teaching practices on learners' mathematics performance. The influence of levels of teacher qualification and years of teaching experience on the mathematics performance of learners were investigated.

4.1 What is secondary data analysis?

SDA refers to the analysis of a data set that was collected to provide information for a different research problem (Essays, 2013). The TIMSS study is conducted to provide information on mathematics and science achievement in the context of the students that participate worldwide every fourth year. Questionnaires provide information on student and teacher background, curricular implementation and instructional practices taking into account the different educational systems and school organizational approaches (Mullis et al., 2009).

One of the biggest advantages of using secondary data for analysis is the economic implications for the study. Collecting, cleaning and storing data are expensive and time consuming tasks. Researchers can benefit from the use of secondary data since the scale of data collection and the frequency of repetitions of tests allow for the detection of trends and changes over time that would be impossible for an individual researcher to achieve (Crossman, 2014). The level of expertise and professionalism of staff members in the data collection and capturing process is yet another advantage of the use of secondary data (Boslaugh, 2007).

A limitation of SDA is that the researcher does not have control over the data collection process and the information contained in the data set (Elliott, 2015). This may include the scales/categories used (Crossman, 2014). Even the geographic region and population description of the chosen data may not be suitable to answer the researcher's specific questions. Low response rates or respondent misunderstandings of specific survey questions are not always communicated and could also be a limitation to the study (Crossman, 2014). Fortunately, since the research questions were aimed at the influence of teachers on the performance of South African learners, the population that participated in TIMSS 2011 suited the purpose of the research. The fact that the researcher did not participate in the collection may however be regarded as a limitation of the study as specific nuances in the collection process could not be considered.

The challenges faced by using SDA were countered by analysing the TIMSS questionnaires beforehand to see whether the responses on the questions in the TIMSS data set would provide insight on the research questions of this study. Furthermore, attention was given to the scales and variables used and information provided on response rate and problems encountered. This information provided the researcher with the necessary knowledge on the data available and whether the data set was useful in answering the research questions. As discussed in the previous paragraph, the population already matched the population that this research was aiming at. Furthermore, the teacher background questionnaire provided information regarding the teacher's highest level of education and experience. This information could then be related to the learner mathematics scores that were also released. Since the teacher information and learner performance scores could be linked, the researcher was able to address the research question.

4.2 Background to TIMSS 2011

South Africa, among 63 countries around the world, took part in the TIMSS 2011 and the Progress in International Reading Literacy Study (PIRLS 2011), an initiative of the International Association for the Evaluation of Educational Achievement (IEA). The IEA is an independent, international cooperative of national research institutions and governmental research agencies that conduct large-scale comparative studies on educational achievement and other aspects of education (http://www.iea.nl).

TIMSS 2011 was the fifth assessment in the framework of the IEA study on the mathematics and science performance of learners internationally. Previous cycles conducted in 1995, 1999, 2003 and 2007 respectively, provided information that could be valuable in establishing trends in learner achievement in mathematics and science. "TIMSS 2011 gathered information about the contexts for learning mathematics and science from participating students, their teachers and their school principals, as well as data about the mathematics and science curricula in each country" (http://www.iea.nl).

The purpose of TIMSS 2011 was to provide quality sets of data for evidence-based educational policy and reform. Achievement data in mathematics and science, accompanied by information from learners, schools and teachers can help countries to determine the level of performance of essential subjects for further study and compare relative strengths and weaknesses in reading, mathematics and science results with international results. Progress can be assessed over time (the database of PIRLS and TIMSS expand every four years). The data also provide information on schools' curricula and instruction for national and local policy. In-depth information on school environments, resources and instruction are gathered and concerns about equity in learning opportunities can be investigated (http://www.iea.nl).

In 2011, the TIMSS survey was conducted on learner performance at the Grade 8 level. Botswana, South Africa and Honduras participated at the Grade 9 level (Reddy, 2012a). The results of the 2011 cycle (fifth cycle) of TIMSS were announced in Amsterdam in December 2012 (http://www.iea.nl). The Human Sciences Research Council (HSRC) conducted the study on behalf of the IEA in

South Africa as the National Research Coordinator. The sample consisted of 285 schools. Nearly 12 000 Grade 9 learners participated (Reddy, 2012b).

Apart from assessing learner's knowledge of mathematics and science, the TIMSS questionnaires directed at learners, teachers and schools provide information about the environment in which learning occurs. The data obtained can be used to explore factors that may have an influence on the mathematics and science performance of learners (Plomp & Howie, 2006). TIMSS 2011 data were collected in a school context concerning three different components, namely learner and teacher background, the schooling process (school environment and curriculum) and learner achievement in the mathematics tests.

5 Data types

A summary of types of data is given in Section 5.1 after which the data used in this research is typified in Section 5.2.

5.1 Types of data

Variables can be classified as either categorical or continuous, and have different levels of measurement (Field, 2013). A summary of the different levels of measurement can be found in Table 3.

Table 3: Levels of measurement

Categorical		Numerical/Continuous	
Nominal	**Ordinal**	**Interval**	**Ratio**
Variables are "named" (could be binary)	Variables have an inherent order-hierarchical	Equal intervals=equal differences	Same as interval, ratios of scores on the scale must make sense
E.g. Gender	E.g. Agreement level	E.g. Rating of lecturers	E.g. Reaction time

5.2 Types of data in this research

For the purpose of this study, the mathematics achievement files of the grade nine learners of South Africa, and the responses of the background questionnaires directed to the teachers involved in their teaching, were used as the variables to be analysed. The level of measurement of mathematics achievement was continuous and responses on the background questionnaire were categorical with only a few items that were continuous e.g. number of years teaching.

6 Instruments

The TIMSS 2011 mathematics assessment of South African learners was used to answer the research questions of this study. This section contains, firstly, a discussion of the instruments developed for the TIMSS 2011 assessment, more specifically, the mathematics and science achievement tests and the background questionnaire directed at the involved teachers. Then, the items (only a subset of the TIMSS instruments) used to answer the research questions are highlighted.

6.1 Instruments developed for the TIMSS 2011 assessment

Test items and scoring guides for the TIMSS 2011 assessments were developed by the staff of the TIMSS and PIRLS International Study Center who is experienced in the measurement and assessment of mathematics and science knowledge and reading achievement and in developing questionnaires. The National Research Coordinators (NRCs) of the participating countries also play a key role in the development and choice of test items, the translation process and the implementation of the study in their countries. The linguistic features of the items are carefully reviewed to ensure the validity and reliability of the instrument. The instrument development processes are guided and reviewed by two expert advisory committees: The Science and Mathematics Item Review Committee (SMIRC) and the Questionnaire Item Review Committee (QIRC).

The instruments used for the TIMSS 2011 assessment include

- mathematics and science achievement tests administered to Grade 8 learners (in South Africa Grade 9)
- background questionnaires directed at the learners, the mathematics and science teachers involved in their teaching and the school principals of the sampled schools to explore the contexts for teaching and learning
- a curriculum questionnaire completed by the NRCs of participating countries that provides information about the mathematics and science curriculum implemented.

The information provided in the following sections regarding the assessment is described in the TIMSS 2011 Assessment Frameworks (Mullis et al., 2009).

6.1.1 Mathematics and Science achievement tests

One of the major goals of the TIMSS assessment is to provide reliable measurement and a comprehensive description of the mathematics and science knowledge and understanding of learners. A wide-ranging assessment is developed to cover the mathematics and science curriculum taught in the classrooms and measures trends in achievement globally.

Apart from the mathematics and science content, a range of cognitive skills, necessary to be able to respond correctly to the items, is also being assessed. Since the research problem concerns only the mathematics performance of the learners, only information on mathematics is discussed. A summary of the mathematics content and cognitive domains tested in Grade 8 (Mullis et al., 2009) can be found in Table 4.

Table 4: Mathematics content and cognitive domains tested in Grade 8

Content domains
Number (30%)
Algebra (30%)
Geometry (20%)
Data and Chance (20%)

Cognitive domains
Knowing (35%)
Applying (40%)
Reasoning (25%)

Items developed to test each content domain (for example algebra) aims to assess the degree of acquiring of the content at different cognitive levels. Learners should know the facts, concepts and procedures, be able to apply knowledge and conceptual understanding in problem solving and use reasoning abilities to solve complex and multistep problems.

In the light of the different cognitive domains being assessed, items are either in multiple-choice (four response options per item provided) or constructed-response (the learner has to construct his or her own written response) format. The item format depends on the mathematics domain being tested, and also on the type of response that will best demonstrate a learner's proficiency in mathematics. A few aspects of multiple-choice and constructed-response items are illustrated in Table 5. The examples used in Table 5, were retrieved from Appendix B of TIMSS 2011 Assessment Frameworks (Mullis et al., 2009).

Table 5: Multiple-choice vs constructed-response items

Multiple-choice items	**Constructed-response items**
Example: Which of these is equal to $2(x + y) - (2x - y)$? ● $3y$ Ⓑ y Ⓒ $4x + 3y$ Ⓓ $4x + 2y$	**Example:** Joe knows that a pen costs 1 zed more than a pencil. His friend bought 2 pens and 3 pencils for 17 zeds. How many zeds will Joe need to buy 1 pen and 2 pencils? Show your work. Pencil : x zeds Pen : $y = x+1$ zeds $2y + 3x = 17$ $2(x+1)+3x = 17$ $2x+2+3x = 17$ /-2 $5x = 15$ /$:5$ $x = 3$ One pencil costs 3 zeds. $y = x+1$ $y = 3+1 = 4$ One pen costs 4 zeds. $x + 2y = 4+2 \cdot 3 = 4+6 = 10$ One pen and two pencils cost 10 zeds.
Responses: Four response options per item provided	**Responses:** Learners provide explanations (either numerical or visual (diagrams)) supporting their responses
Scoring: Correct answer is called the key	**Scoring:** Scoring guides compiled to train scorers, consistency important
Purpose: To test a learner's content knowledge	**Purpose:** Common learning difficulties in mathematics as shown by misconceptions and errors can be identified by the responses on the constructed-response items

The TIMSS 2011 assessment items pools consist of 217 mathematics and 217 science questions (items). The mathematics and science items are divided into 28 item blocks, 14 mathematics blocks and 14 science blocks respectively, as illustrated in Table 6. Each item block consists of twelve to eighteen items either in multiple-choice or constructed-response format. The mathematics item blocks are labelled M01 to M14 and the science item blocks S01 to S14.

Table 6: Items divided into item blocks

Mathematics items pool **217 items in total**							**Science items pool** **217 items in total**						
Multiple-choice format			**Constructed-response format**				**Multiple-choice format**			**Constructed-response format**			
12 – 18 items per item block							**12 – 18 items per item block**						
M01	M02	M03	M04	M05	M06	M07	S01	S02	S03	S04	S05	S06	S07
M08	M09	M10	M11	M12	M13	M14	S08	S09	S10	S11	S12	S13	S14

After each TIMSS assessment, item blocks to be released to the public are identified and new items are developed to include in the next assessment. Eight of the item blocks are retained to enable the measurement of trends in the mathematics performance of learners. The item pool development process between two consecutive assessments is illustrated in Figure 3.

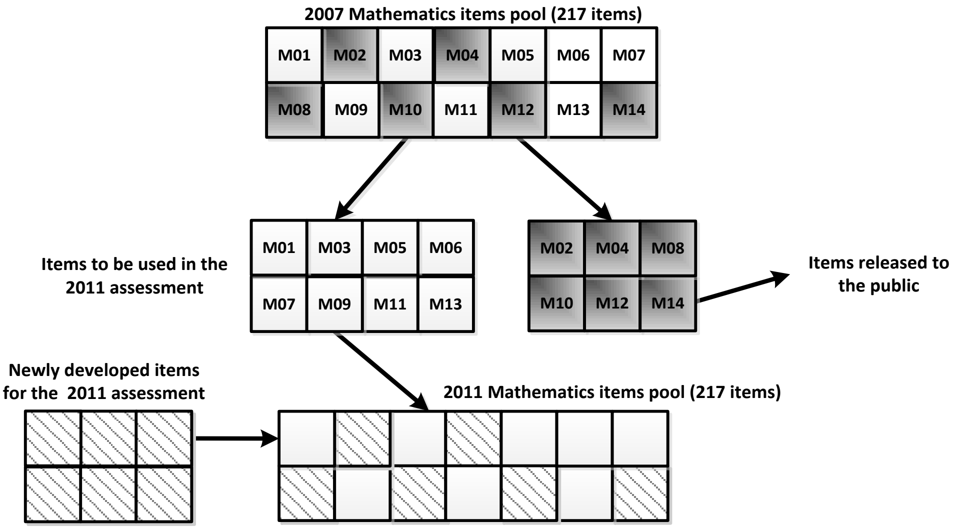


Figure 3: Item pool development process

Every learner cannot be assessed on all the test items in the item pools, giving rise to the booklet design of the TIMSS assessment. Fourteen learner achievement booklets are developed (using a matrix sampling approach) by selecting four item blocks (two blocks of mathematics and two blocks of science) to include in each booklet. The booklet is divided in two parts: one part consisting of the two mathematics blocks (a block used in the TIMSS 2007 assessment together with a block containing newly developed items for the TIMSS 2011 assessment) and the other of two science blocks (a block used in the TIMSS 2007 assessment together with a block containing newly developed items for the TIMSS 2011 assessment). One booklet contains sufficient items to be answered by one learner to ensure the reliability of the measurement. The design of the booklet is illustrated in Figure 4.

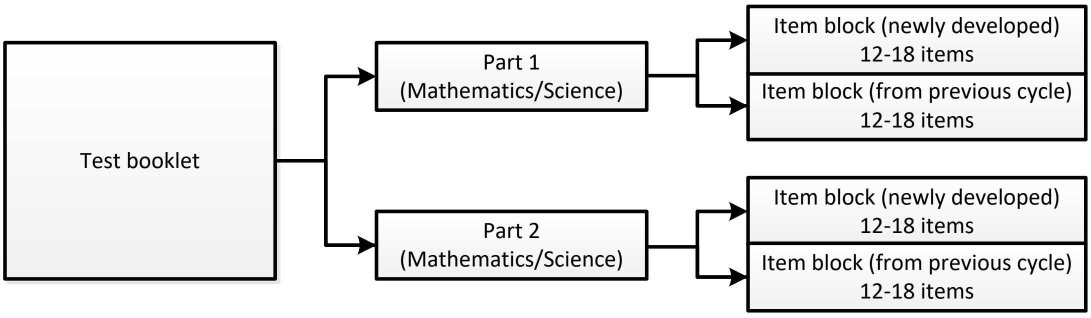


Figure 4: Test booklet design

The order of the presentation of the mathematics item blocks and the science item blocks changes between the different booklets. The distribution of the mathematics and science item blocks between the test booklets (Mullis et al., 2009) can be seen in Table 7.

Table 7: Distribution of item blocks in the test booklets

Booklet	Part 1		Part 2	
1	M01	M02*	S01	S02*
2	S02*	S03	M02*	M03
3	M03	M04*	S03	S04*
4	S04*	S05	M04*	M05
5	M05	M06	S05	S06
6	S06	S07	M06	M07
7	M07	M08*	S07	S08*
8	S08*	S09	M08*	M09
9	M09	M10*	S09	S10*
10	S10*	S11	M10*	M11
11	M11	M12*	S11	S12*
12	S12*	S13	M12*	M13
13	M13	M14*	S13	S14*
14	S14*	S01	M14*	M01

*Item block containing newly developed items for TIMSS 2011

The 14 learner booklets are dispersed to leaners in each sampled class so that equal numbers of each booklet are implemented. Each learner only receives one booklet to complete in 90 minutes with a break between the two parts. Learner responses from the different booklets can be linked together because each item appears in two booklets.

After the assessment results for TIMSS 2011 have been published, six of the fourteen item blocks in each subject are released to be used as instructional materials (as extra examples or test items) by teachers or for further research purposes. Trends in the mathematics and science performance of learners (globally and nationally) are measured by re-administering the secured items (items not released to the public) in future TIMSS cycles.

6.1.2 Questionnaires exploring contextual framework

A learner's achievement is typically influenced by numerous factors. Understanding of the contexts in which learning takes place is therefore essential to facilitate improved learner achievement. The TIMSS background questionnaires are thus directed at the learners, the teachers involved in their teaching and the principles at the sampled schools. Through these questionnaires, important information on procedures and practices, shown to elevate mathematics and science achievement, is collected. Factors like the type of school, school resources, instructional approaches, teacher characteristics, student attitudes, parent background and home support for learning are addressed in these questionnaires.

Teachers play an important role in the mathematics achievement of learners (Rimm-Kaufman & Sandilos, n.d.). Therefore, information regarding the teacher's education, professional development and experience in teaching is gathered through the teacher background questionnaire. Apart from the background information, the teachers' views on opportunities for collaboration with other teachers, teaching the subject matter and of their job satisfaction levels, are also gathered. The teaching of mathematics is explored around instructional time, the use of computers in teaching, assessment practices, homework, instructional practices that increase motivation and how teachers promote learners' interest in the subject. The teacher questionnaire can be completed in approximately 30 minutes (Mullis et al., 2009).

6.2 Instruments used in the current study

The influence of level of education and teacher experience on the mathematics achievement of learners was the focus area of this study. In order to address the research problem, the responses on questions one to five were used to provide insight into the profile of the teachers involved (See Table 8). Information regarding age, gender, years of teaching experience, the teachers' major or main area of study, and the highest level of formal education achieved were obtained in this manner. The options provided in the question concerning the highest level of formal education differ between countries for obvious reasons.

The teacher responses to questions one to five (the questions are displayed in Table 8) together with the results of the mathematic achievement tests administered to the learners were used to investigate the influence of certain teacher credentials on the mathematics performance of learners.

Table 8: Extraction of questions in the teacher background questionnaire

1

By the end of this school year, how many years will you have been teaching altogether?

_______________ years

*Please **round** to the nearest whole number.*

2

Are you female or male?

*Check **one** circle only.*

Female--- ◯

Male--- ◯

3

How old are you?

*Check **one** circle only.*

- Under 25 --- ◯
- 25–29 --- ◯
- 30–39 --- ◯
- 40–49 --- ◯
- 50–59 --- ◯
- 60 or more --- ◯

4

What is the <u>highest</u> level of formal education you have completed?

*Check **one** circle only.*

a) Did not complete Grade 12---- ◯

b) Passed Grade 12---- ◯

c) Obtained a post-matric certificate ◯

d) Obtained a diploma ◯

e) Obtained a first degree ◯

f) Obtained an honours degree+ ◯

5

During your <post-secondary> education, what was your <u>major or main</u> area(s) of study?

*Check **one** circle for each line.*

	Yes	No
a) Mathematics	◯	◯
b) Biology	◯	◯
c) Physics	◯	◯
d) Chemistry	◯	◯
e) <Earth Science>	◯	◯
f) Education–Mathematics	◯	◯
g) Education–Science	◯	◯
h) Education–General	◯	◯
i) Other	◯	◯

7 Sampling and Participants

A sample is “a finite part of a statistical population whose properties are studied to gain information about the whole” (Merriam-Webster, 2015). Sampling refers to the methods followed in the selection of the participants to the study from a population (Trochim, 2006c). Sampling methods are categorised as being either probability sampling where every member of the population has an equal chance to be part of the sample, or non-probability sampling where some members of the population do not have a chance to be part of the sample (Statistical Sampling, 2016). Probability sampling methods enable the researcher to generalise the findings to the population.

7.1 TIMSS sampling procedures for South Africa

The TIMSS assessment aims to give a realistic image of the mathematics achievement of learners at two grade levels in all of the participating countries (http://www.iea.nl). The target population of the assessment is defined by considering the number of years of formal schooling that a learner has received (http://www.iea.nl). For the purpose of this study, the target population will be Grade 9 learners in South Africa.

Every learner cannot be tested since there are too many learners, it is too expensive and there are too many items to be assessed. The sampling procedures need to comply with the reporting goals set out by TIMSS, giving a realistic estimation of learner achievement in mathematics by only assessing a sample of learners in a sample of the schools in South Africa. The national target population of each participating country needs to be defined and a nationally representative sample of schools and learners needs to be identified. The country's NRC together with the TIMSS sampling experts develop and implement a national sampling plan that complies with the TIMSS sampling standards. The country's NRC, guided by a series of manuals, has to first pinpoint the grade of learners corresponding to the international target population, and then list all the schools in the population with classes of learners in the target grade creating a school sampling frame for the target population. The TIMSS international guidelines in determining the national population coverage and exclusions should be applied to aid the development of a national sampling plan in conjunction with Statistics Canada who is responsible for advising in respect of the National Research. Stratification variables (for example region of the country; school type or source of funding; language of instruction; level of urbanization; socio-economic indicators and school performance on national examinations) that are present and correct for all schools need to be identified. The NRC's have to exclude schools (due to inaccessibility, school size, and more) and learners (due to functional and intellectual disabilities or non-native language speakers) if necessary (http://www.iea.nl).

After all of these preparations, the NRC's should administrate the sampling process. They should contact sampled schools to safeguard their participation and keep track of school participation and the use of replacement schools if necessary. They even have to control the sampling of classes within the schools, and finally have to ensure that the national sample is fully acceptable (minimum school participation rate of 85%; minimum classroom participation rate of 95% or minimum combined school, classroom and student participation rate of 75%). The population coverage and school and learner participation rates are documented after which appropriate sampling weights, to be used in analysing the results, are constructed (http://www.iea.nl).

In TIMSS, the learner sample is drawn in two steps: the selection of schools and then the selection of intact classes within the selected schools. Intact classes are used to limit disruption of the school's activities and because the learner's curricular and instructional experiences (organised on classroom basis) are considered to be one of the important influences on learner achievement. A stratified two-stage cluster sample design is used (http://www.iea.nl).

In stage one the South African population is divided into 29 explicit strata by using the nine provinces (South African Provinces | Money Transfer South Africa, 2011) (illustrated in Figure 5), three instruction languages and the three school types (described in Figure 6) respectively. Using the school sampling frame provided by the NRC, schools (and two replacement schools) that contain eligible students are sampled by Statistics Canada by using a systematic random sampling approach in each of the strata.

Figure 5: South African provinces

There are 25 851 schools in South Africa: 94.3% public, and 5.8% independent. The public schools provide education to 96.1% and the independent schools 3.9% of the 12 283 875 learners in South Africa.

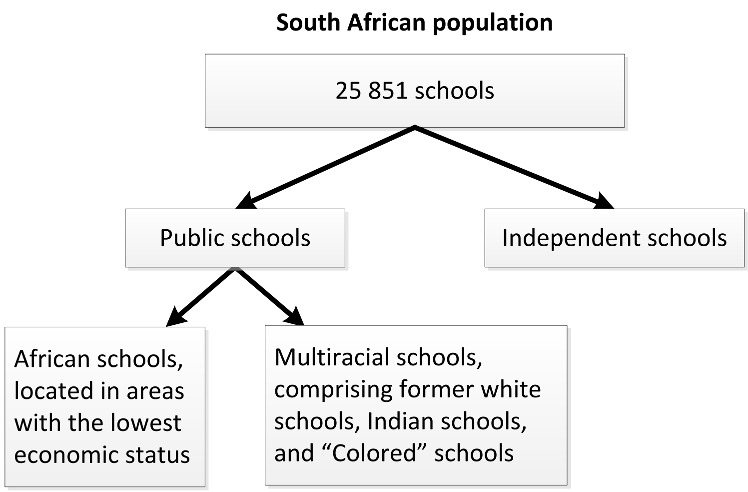


Figure 6: Types of schools in South Africa

The number of schools sampled in each of the 29 strata (Foy, Arora & Stanco, 2013) is recorded in Table 9.

Table 9: Explicit strata used in South Africa

Strata (Province and language)			
Province	**Afrikaans**	**English**	**Afrikaans and English**
Eastern Cape	2	18	4
Free State	2	15	4
Gauteng	6	21	4
Kwazulu Natal	2	30	2
Limpopo	2	16	2
Mpumalanga	3	27	2
Nothern Cape	9	7	5
Northwest	4	15	2
Western Cape	7	5	10
Strata (school types)			
Public and Dinaledi*	30		
Independent	29		

*Dinaledi schools are schools that receive a grant from the government aimed at increasing access to mathematics and science at higher-grade level in underprivileged schools (Department of Education, 2009).

After securing the sampled school's participation in the TIMSS assessment, the NRC obtains information regarding the number of classes and teachers in the school to enter in the WinW3S, the sampling software developed by the IEA DPC and Statistics Canada. In the second stage, classes with equal probabilities within schools are selected to participate by using the sampling software WinW3S. The

NRC of each country (in South Africa the Human Sciences Research Council - HSRC) handles the class sampling process. Every student in the sampled class participates in the assessment (Mullis et al., 2009).

7.2 Sample used in current study

The sample for the current research consisted of Grade 9 learners and their respective teachers in South Africa that were sampled to participate in TIMSS 2011. South Africa was first divided into different strata before the schools in the strata were listed according to the type of school. The schools were then chosen randomly. After the selection of the schools, the classes in the schools were listed and also chosen randomly. The teacher and the learners in a particular class, however, were all part of the sample because of the fact that their class had been selected. Since a stratified two-stage cluster sample design was used for the TIMSS 2011, weights had to be applied to generalise the findings to the South African population. For TIMSS 2011 in South Africa, data was collected in 285 schools: 256 public ordinary schools and 29 independent schools. A total of 327 teachers and 11 969 learners participated.

8 Data collection methods

First attention is given to the TIMSS data collection methods and then to the data used in his research.

8.1 TIMSS data collection methods

Data in the TIMSS assessment is collected concerning the level of mathematics knowledge and competence of learners in Grade 8 internationally (but Grade 9 in South Africa, as previously noted) and also the context in which learning takes place.

Data on the level of mathematics knowledge and competence of learners is gathered by means of a mathematics test described in Section 6.1.

The context in which learning takes place is explored by means of surveys completed by the learners, the teachers involved in their learning, the school principles of the sampled schools and the NRC of the country. The responses on the surveys can provide information regarding the knowledge and ability of learners in mathematics and the context in which learning takes place. The background information gathered by means of surveys describes the current context of learning while the learning might have occurred a while back. Statements about correlations between various factors can be made by using the information collected by the surveys. The causality or direct effect of the level of performance however needs to be established by other statistical means. Surveys as assessment tools are cross-sectional and can be repeated over time.

The TIMSS assessment aims to give a reliable profile of the mathematics and science achievement and learning contexts of learners in the participating countries. Even though the instruments were developed in close collaboration with the participating countries, the quality of the data collected is dependent on the approach of each individual country. To guarantee that the data collected will be of high quality, suitable to use to evaluate and compare the performance of learners worldwide, a set of standardised operations procedures was developed and distributed to representatives in the participating countries (http://www.iea.nl).

The National Research Coordinator (NRC) has different responsibilities. Internationally the NRC, as contact person for all project activities, represents the participating country at meetings for TIMSS. Locally the NRC is in charge of the implementation of the procedures and facilitation of national decisions with regards to TIMSS. To guide the NRCs in the administering of the TIMSS assessment activities, step-by-step documentation, the Survey Operations Procedures (Johansone, 2013), is provided by the TIMSS International Study Center. The NRCs role and the guidance provided during the data collection process is summarised in Table 10.

Table 10: NRC's role and guidance provided in the data collection process

Task	Activities	Guidance provided
Identification and selection of samples	• Sampling both schools and classes within the sampled schools	• Within-school Sampling Software (WinW3S) to sample class(es) within the school • WinW3S tracked school, teacher, and student information
Preparation of the survey instruments	• Translating, adapting, assembling, and printing the test materials • Checking the materials and securely storing them.	• IEA Secretariat provide an independent translation verification • Adobe®InDesign® software: to link the translated and adapted assessment blocks to the appropriate booklets • Survey Operations Procedures provide instructions on how to use the materials to produce high quality, standardized instruments
Administering of the assessment(s)	• Identifying and training School Coordinators for all participating schools. • Tracking forms and instrument labels which facilitated the assessment during the data cleaning process	• Generated by WinW3S • SurveySystem Designer: administer online questionnaires
Implementation of the National Quality Control Program	• National Quality Control Observers (NQCO): observe the test administration	• School visits by International Quality Control Monitors (IQCMs)- interviewed School Coordinators
Preparation for and scoring of the constructed-response items	• Recruitment and training of scoring staff to score student responses • Intensive training in constructed-response item scoring	• Two international scoring training sessions • Scoring guide

Task	Activities	Guidance provided
	• Independent double scoring to verify scoring reliability	
Creating the data files	• Data entry and quality control • Intensive training in data management.	• WinW3S software and/or the Windows Data Entry Manager (WinDEM)-data and file management capabilities, a convenient checking and editing mechanism, interactive error detection, and reporting and quality-control procedures • Performing periodic reliability checks • Optical scanning instead of manual data entry.

For quality insurance the “Survey Activities Questionnaire” was developed to gather information regarding the NRCs encounters before and during the process of administering the TIMSS assessment (http://www.iea.nl). The items in the questionnaire focus on the tasks identified in Table 10.

The NRC for each country has to appoint School Coordinators (a teacher or guidance counselor in the school or a member of the national center). The School Coordinator Manual outlines the responsibilities of the school coordinator. The school coordinator should provide information for the sampling process (data on eligible classes in the school) and ensure that every student in the school was listed in one and only one class (course). He or she should coordinate the date, time and place for testing and identify and train a Test Administrator to administer the assessment. Parental permission (if necessary) should be obtained and the TIMSS 2011 and/or PIRLS 2011 tracking forms need to be completed. The Test Administrator, guided by the Test Administrator Manual, administers the assessment (achievement booklets) and Student Questionnaires in each sampled class. Apart from the distribution of materials to the learners by using the Student Tracking Form and labels, the Test Administrator also has to coordinate the documentation of learner participation. He or she is responsible for the documentation of the procedures followed (reading of the instructions and the timing of testing sessions) and has to ensure that the participation rate is more than 90%. Furthermore, he or she has to ensure the return of all of the abovementioned documents and assessment booklets to the national center following the administration of the assessment(s) (http://www.iea.nl).

A full-scale field test of the instruments and operational procedures are conducted to acquaint the NRCs and their staff with the activities. Apart from the series of manuals provided to the NRCs, School Coordinators and Test Administrators, a range of custom-built software products are also implemented to streamline and automate the assessment process. Efficiency and accuracy are enhanced by updating the operations procedures with each TIMSS cycle, and by implementing developments in information technology with the aim of automating routine activities (http://www.iea.nl).

8.2 Data collected for the current study

TIMSS collected data globally in two grade levels: Grade 4 and Grade 8 respectively. For the purpose of this study only the data collected in South Africa and only the data of the Grade 9 learners (our equivalent to Grade 8 learners elsewhere) were used in the data analysis.

9 Data access

For the purpose of secondary data analysis, access to the data set is important. Information regarding TIMSS International Database can be found in Section 9.1 and the data extracted for the purpose of this study is discussed in Section 9.2.

9.1 TIMSS International Database

The data collected in the participating countries were compiled in an International Database that can be downloaded from the TIMSS 2011 International webpage or from the IEA Study Data Repository website (http://rms.iea-dpc.org/) and is presented in both SPSS and SAS formats.

The dataset provided by TIMSS contains the mathematics and science results of 63 countries and 14 benchmarking participants worldwide in the following areas of enquiry: the learner background and performance, teacher and school background, within-country scoring reliability and student–teacher linkage files (Mullis et al., 2009). A summary and short description of the contents of the TIMSS 2011 International Database (Mullis et al., 2009) is provided in Figure 7.

9.2 Data extracted for the current study

Only the data obtained from the background questionnaires administered to the South African Grade 9 learners' mathematics teachers and the results of the Grade 9 mathematics achievement tests (of South Africa), were extracted from the TIMSS repository to include in the dataset that was used in the research.

The data obtained from the different background questionnaires directed at the learners, the teachers involved in their learning, the school principals of the sampled schools and the achievement of the learners, were organised in separate data files.

The items evaluated in the different questionnaires had a specific code related to the file. The file names used in the data documentation are listed and described in Table 11.

Table 11: Learner, teacher and school data files

Student, teacher and school database	
File name	**File description**
bcgzafm5.sav	Eighth grade school background data files
bsazafm5.sav	Eighth grade student achievement data files
bsgzafm5.sav	Eighth grade student background data files
bsrzafm5.sav	Eighth grade within-country scoring reliability data files
bstzafm5.sav	Eighth grade student–teacher linkage files
btmzafm5.sav	Eighth grade mathematics teacher background data files

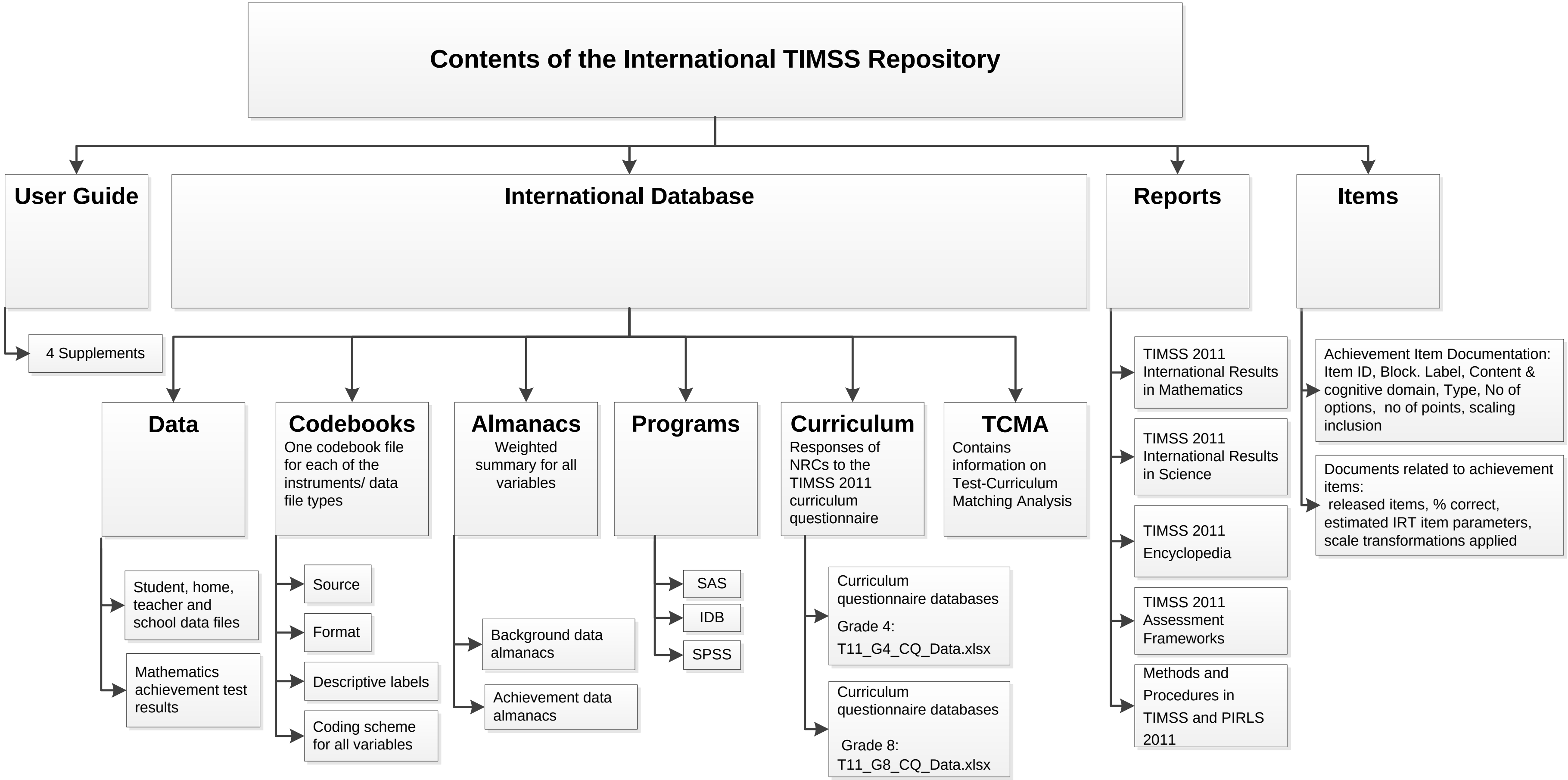


Figure 7: Contents of the International TIMSS Repository

The data applicable to this study were found in the eighth grade student–teacher linkage files (bstzafm5.sav), the eighth grade mathematics teacher background data files (btmzafm5.sav) and in the eighth grade student achievement data files (bsazafm5.sav).

10 Statistical tests

The choice of statistical procedures for the analysis of the data depended on the sampling properties of the TIMSS dataset. The TIMSS sample (as described in Section 7.2) was drawn using a two-stage cluster sampling technique. Since the research aimed to explore the influence of certain teacher credentials on the mathematics performance of learners in South Africa, the interest did not only fall on the properties of the sample as such but on the properties of the population the sample was drawn from. To obtain correct estimates, representative of the target population, weights had to be used (Foy et al., 2013). The five sets of weights and where it should be used in the analysis of the dataset are summarized in Table 12.

Table 12: Five sets of weights

Kind of weight	Adds up to	Use when
Total student weight (TOTWGT)	• The estimated size of the student population • Adjust for over- or under-representation of particular groups • Sum of student weights=number of students in target population	• Student-level statistical analysis • When working with teacher variables single-level student level analyses
Student house weight (normalized weight) (HOUWGT)	• A linear transformation of total student weight so that the sum of the weights is equal to the sample size	• Analyses are sensitive to sample size • Cross-country analysis (countries treated equally)

Kind of weight	Adds up to	Use when
Student senate weight (SENWGT)	• Student total weight scaled in such a way that all students' senate weights sum to 500 in each country	• Analyses involve more than one country
Overall and subjectwise teacher weights (TCHWGT or MATWGT/SCIWGT)	• Based on total student weight TOTWGT for a student divided by the number of teachers for that student	• Analysing teacher datasets as attributes of the student
School weights (SCHWGT)	• The estimated number of schools in the country • Incorporates probability of selection for the selected school	• When working with school data by itself analysing school-level data

The estimates obtained from analysing the TIMSS dataset are not precise since all of the learners in the target population are not tested and all of the items in the items pools cannot be administered to all of the sampled learners. Another challenge arises because of the cluster sampling design. Learners within the sampled schools will share some characteristics since they originate from the same social context unlike learners that are randomly selected from the population of all learners. The difference in the variance of a random selected sample and a complex sampling design as being used in the TIMSS assessment require appropriate analysis procedures and the use of the software program provided, the IEA IDB Analyzer© (http://www.iea.nl).

To determine the accuracy of the estimates considering the sampling and imputation variability, standard errors need to be computed. In TIMSS the standard errors are computed by using a Jackknife Repeated Replication Technique. Differences between estimates from the full sample and a series of replicate samples are used to calculate the correct standard errors. The Jackknife replication information, contained in JKZONE and JKREP, can be used to compute the standard errors with the aim of creating confidence intervals for statistics computed from the TIMSS data (http://www.iea.nl).

The TIMSS assessment is designed to report on the subject area(s) without overburdening the students. Given that the assessment items are distributed among 14 booklets and a learner only responds to one of these, learner achievement is summarized on a common scale using the Item Response Theory (IRT). The difficulty of items is not reflected in the raw scores and therefore a scale that reflects both learner performance and item difficulty simultaneously is needed. IRT gives an indication of the performance of a learner as if he/she has completed the entire assessment. The ability of a learner and the parameters of the item administered, influence the likelihood of a correct answer. Five estimates or "plausible values" are drawn from learners with similar item response patterns and background characteristics ensuring optimal estimates for each national sample (http://www.iea.nl).

In order to verify quantitatively that the achievement of Grade 9 mathematics learners is influenced by different teaching strategies, the IDB Analyzer and SPSS were used. The IDB Analyzer "creates SPSS code that can be used with SPSS to conduct statistical analyses, taking into account the complex sample structure of the databases" (http://www.iea.nl).

SPSS was used to compare the sample to a theoretical parameter to determine the goodness of fit by applying the Chi-square (one-way and two-way) test. Furthermore, the transformation of the variables (years of teaching experience) was also done in SPSS. The years of teaching experience ranged from one to 43 years. The data (continuous variable) was grouped into a smaller number of categories (bins). This statistical method, called data binning, is used to group continuous values into a smaller number of bins. More details on the choice of the number of bins are given in Chapter 4 Section 3.

The IDB Analyzer's graphical user interface contains two modules: Merge and Analysis. The Merge Module is used to merge data from different respondents. In this study the data contained in the teacher background questionnaire (btmzafm5.sav) and the learner achievement data files (bsazafm5.sav) are merged by using the linking file (bstzafm5). The Analysis Module is used to compute means, percentages, standard deviations and correlations and other statistics using the plausible value methodology (http://www.iea.nl). Differences across the groups (teachers with different levels of education and teachers with different numbers of years of experience) with regards to the mathematics performance of the learners are evaluated by using linear regression. The mathematics performance of learners is the dependent variable and the teacher credentials act as the independent variable. Since the independent variables have more than two categories, effect coding is used. Dummy coding is used where the independent variables have only two categories. The regression coefficients, together with their standard errors, are computed with contrast coding of the categorical independent variable. Since the variable that is used as the reference variable is not computed, the computation is done a second time, with another variable as reference. The two outputs are then merged to have all of the results in one table.

Methods to replace missing data by using the IDB Analyzer include Pairwise, Listwise and MeanSubstitution. Since some of the responses to the statements used in the data analysis are ordinal variables, MeanSubstitution cannot be used as method to replace missing data. MeanSubstitution is used to replace missing continuous variables with the mean for the variable. In the Pairwise option, cases with missing data are ignored for the purpose of the calculations regarding the specific variable and not totally removed from the dataset as is the case with the Listwise option (http://www.iea.nl). Since the TIMSS sample is fairly large, the Listwise option, was used to treat the missing data.

The unit of analysis in the proposed study is the Grade 9 mathematics learners who participated in TIMSS 2011 and their mathematics achievement scores. The background questionnaire completed by the mathematics teachers involved with the learners at selected schools in South Africa, will be used to investigate the influence of the different teacher credentials on the mathematics performance of the learners. The learner will remain the unit of analysis, since the information will be reported in terms of the percentage of learners whose teachers had certain teacher credentials or not.

11 Validity and reliability

The quality of the research process and the end product depends on the reliability and validity of the measurement instruments (Mentz & Botha, 2012). This section starts off with the general definitions for reliability and validity. Then attention is given to the measures that were put in place by the TIMSS assessment to ensure the validity and reliability of their instrument. Lastly, the reliability and validity regarding the current research are considered.

Reliability refers to the consistency and repeatability of the measuring instrument (Wagner, Kawulich, & Garner, 2012). In other words, an instrument is reliable when the same results are obtained when the instrument is re-administered to the learners on a different occasion (test-retest reliability) and also when the administering of a similar instrument gives the same results (equivalent form reliability) (Pietersen & Maree, 2012). Pietersen & Maree (2012) further state that the reliability of an instrument could also be established by dividing the items that form part of the instrument in two, each part to be used as a separate instrument (split-half reliability) in order to find the correlation coefficient between the two newly constructed instruments. And finally they refer to a measurement of inter-item correlations, items that are intended to measure the same construct render the same results (internal reliability or consistency) (Pietersen & Maree, 2012).

The term “validity” and the different types of validity defined are interpreted slightly different between researches. Trochim (2006b) defines validity as the best offered estimate to the truth of a given idea, interpretation, or conclusion. Validity, according to Gravetter and Forzano (2006), refers to the extent to which the instrument is measuring the construct that was intended to be measured. The three types of validity defined by Mentz and Botha are content validity (where the content of the items correlate with the content of the domain tested), criterion validity (comparison between measure against a predetermined set of criteria) and construct validity (coverage of the construct measured by different groups of related items). Pieterson and Maree (2012) added face validity (instrument “looks” valid) to the list of different types of validity. Trochim (2006b) uses four questions in his quest for validity: “Is there a relationship between the cause and effect?” (conclusion validity), “Is the relationship causal?” (Internal validity); “Can we generalize to the constructs?” (construct validity) and “Can we generalise to other persons, places, times?” (external validity).

11.1 TIMSS validity and reliability

The IEA has placed several measures in place to ensure that TIMSS 2011 will provide reliable and valid data for researchers and educational policy makers (see Table 10). The IEA-trained national and international representatives monitor and advise countries in the different stages of the TIMSS project. The questionnaires are developed by representatives from participating countries, taking into account the curriculum coverage of each country. The instrument translation process is also closely monitored to ensure content validity. Fourteen booklets are compiled containing the different subject and cognitive domain blocks, in this way the reliability of the data obtained is ensured (learners receive different booklets). The sampling procedures are specified and enforced in all the participating countries. Operational manuals are provided to guarantee that the achievement tests are administered in the correct way, the collected data is valid, reliable and can be used to make comparisons across countries. Scorer reliability is ensured by distributing a scorer guide and providing extensive training for the scorers in different countries. Furthermore, the IQCMs do quality checks and monitor the double marking of scripts. Aside from the within country reliability scoring, measures to ensure trend reliability scoring are also undertaken. The data is processed twice to eliminate contamination by human error. The Data Processing and Research Center verify and clean the data set even further before releasing the data for research (http://www.iea.nl).

11.2 Validity and reliability for the current study

The reliability of the instrument used in the TIMSS 2011 research was ensured by numerous measures (discussed in the previous section) as enforced by the IEA. Since the researcher only used the data released after the TIMSS 2011 cycle, the reliability of the instrument was not of concern.

The internal, external and conclusion validity did not pose a problem in this research study. Special attention was given to the construct validity, the degree to which a test measures what it claims, or purports, to be measuring. Initially the intention of the research study was also to include the professional development courses that a teacher has attended. The problem was that there was not enough information regarding these courses and as such, the construct validity was at risk. The researcher was also interested in the teaching practices of teachers, and for the same reason (construct validity) the research question had to be changed to rather focus on the qualifications and years of experience of the teachers. The responses of the teachers on the items chosen could pose a problem regarding the validity since teachers could interpret the questions differently and in that way influence the outcome of the study.

The data analysis was done according to the specifications of TIMSS by using the IDB Analyzer that automatically implements the correct weighting values as prescribed. Furthermore, the data analysis was done meticulously, according to the specifications of TIMSS.

12 Assumptions

The researcher accepts the validity and reliability of the instruments used in the TIMSS 2011. The data collection process, capturing of responses and the storage process are assumed to be accurate and flawless. Furthermore, it is believed that the responses of the teachers on the background questionnaire are honest and that the answers are a true reflection of the teacher credentials. Additionally, it is accepted that the administering of the mathematics tests was according to the prescriptions of TIMSS.

13 Ethical considerations

The IEA published the TIMSS 2011 data set free of charge to encourage further research on the educational status of countries; to consider the feasibility of education for future professionals and to evaluate changes over time. The owner of the data, the IEA, has already applied and received ethical clearance internationally. The NRC of South Africa received permission from each provincial department of education (PDOE) (Blignaut, Hinostroza, Els, & Brun, 2010).

For the purpose of this study, ethical clearance had to be obtained from the Ethics committee of the University of Pretoria. After the researcher had completed the online Faculty of Education Ethical Application, the Ethics committee approved the application. Permission to use the TIMSS data was also obtained from the NRC in South Africa.

Since the study is a secondary data analysis, full anonymity and confidentiality are ensured seeing that only the general findings will be outlined. Therefore, the only obligation will be to ensure that the data analysis was done with integrity according to the specifications provided by the IEA, by using the IDB Analyzer and the appropriate weighting structure.

14 Operational Definition of Research Variables

The items related to the teacher background questionnaire that are used in data analysis together with the mathematics achievement files are displayed in Table 13.

Table 13: Variables for the purpose of this study

Items	File name	Field name	Level of measurement
Teacher credentials			
By end of this school year, no of years teaching	btmzafm5.sav	BTBG01	Continuous
Highest level of education	btmzafm5.sav	BTBG04	Ordinal
Mathematics major area of study	btmzafm5.sav	BTBG05A	Nominal
Education mathematics major area of study	btmzafm5.sav	BTBG05F	Nominal
Mathematics achievement			
Overall Mathematics achievement & on subject & cognitive domain	bsazafm5.sav	BSMMAT01 BSMMAT02 BSMMAT03 BSMMAT04 BSMMAT05	Continuous

15 Closure

This chapter dealt with the research design and methodology followed in the research. The post-positivist paradigm was found to fit the quantitative approach necessary to analyse the secondary data that originated from the TIMSS 2011 assessment. The chapter is useful to gain information on the instruments developed for the TIMSS assessment, sampling procedures and data collection methods prescribed. Validity and reliability are also discussed and the assumptions of the researcher are declared. The chapter concluded with the ethical considerations and the constitution of the variables to be used in this study. The next chapter will report on the results of the statistical tests that were proposed in this chapter.

Chapter 4: Analysis of Data and Interpretation of Results

1 Introduction

The research conducted was aimed at clarifying the influence of teaching qualifications, years of experience and the attendance of professional development courses on the mathematics performance of Grade 9 learners in South Africa. The main research question to be addressed was:

- How do the teaching qualifications and years of teaching experience influence the mathematics achievement scores of the Grade 9 learners in South Africa, who participated in the TIMSS 2011?

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

- What does the general profile of the teachers that participated in TIMSS 2011 look like?
- What was the influence of teacher qualification and the years of teaching experience on the mathematics achievement scores of the Grade 9 learners of South Africa who participated in TIMSS 2011?
- Which of the above-mentioned teacher credentials had a significant influence on the mathematics achievement scores of the Grade 9 learners of South Africa who participated in TIMSS 2011?

This chapter starts with a general description of the sample of teachers involved in the research. Secondly, attention is given to the influence of teacher experience on the mathematics performance of the learners. The influence of teaching qualifications and professional development courses attended on the mathematics performance of learners are also investigated.

The data analysis results are described and discussed in this chapter. All p-values are reported to 3 decimal places. The results regarding the influence of the teacher qualities listed in the previous paragraph on the mathematics performance of the learners are illustrated by using line graphs. The results are reported within a 5% level of significance (absolute value of t-test > 1.96) with three asterisks and the 10% level of significance (absolute value of t-test > 1.645) is indicated with two asterisks. Even though a 20% level of significance (absolute value of t-test > 1.28, indicated with one asterisk) seems to be too big, it could be argued that, with a different sample collected under similar circumstances, there could be a significant difference on a 5% or a 10% level of significance. Therefore, we also indicate statistically significant differences on a 20% level of significance.

2 General description of teacher characteristics

A teacher's approach in the classroom is influenced by a variety of factors. Information regarding the teacher's profile such as gender, age group, highest level of education, major area of study (mathematics or education-mathematics), years of teaching experience and attendance of professional development courses are therefore displayed in this section.

The sample of teachers described in this section is not representative of the population of teachers of South Africa because of the sampling procedures followed in TIMSS. Since the study focused on the mathematics performance of the learners, the characteristics of the teachers were reported in terms of, not only the number of teachers involved, but also in terms of the number of learners that were subject to the teacher's characteristics.

2.1 Gender distribution

The gender distribution of the teachers, tabulated in Table 14, showed no significant difference (p-value = 0.203 > 0.05) between male and female teachers, therefore, the teacher could be male or female with equal probability.

Table 14: Gender distribution of teachers

	Number of male and female teachers	Percent	Number of learners taught by male and female teachers	Percent
Female	138	46.3	4 921	44.3
Male	160	53.7	6 191	55.7
Total	**298**	**100.0**	**11 112**	**100.0**
Chi-square p-value	**0.203**		**0.000*** **	

Female teachers (138 teachers) had 4 921 learners in their classes while the male teachers (160 teachers) had 6 191 learners in their classes. Male teachers had on average three more learners per class than the female teachers (male teachers have 6 191/160=38.69 and female teachers 4 921/138= 35.65). When looking at the number of learners taught by male or female teachers, the p-value = 0.000*** (< 0.05) indicated that learners were taught by male and female teachers with unequal probability.

2.2 Age group

Teachers between 30 and 49 years of age taught 65.8% of the learners that participated in TIMSS in their classrooms, as can be seen in Table 15. The teachers were in different age groups with unequal probability (p-value = 0.000*** (< 0.05)).

Table 15: Age of teachers

	Number of teachers in each age category	Percent	Number of learners taught by teachers in each age category	Percent
Under 25	9	3.0	294	2.7
25-29	44	14.9	1 563	14.2
30-39	87	29.4	3 277	29.8
40-49	103	34.8	3 956	36.0
50-59	47	15.9	1 707	15.5
60 or more	6	2.0	198	1.8
Total	**296**	**100.0**	**10 995**	**100.0**
Chi-square p-value	**0.000*** **		**0.000*** **	

2.3 Highest level of education

It is apparent from Table 16 that only 2.8% of the sample of South African learners was instructed by teachers with only Grade 12 or a post matric certificate while 58.8% was instructed by teachers that had obtained either a first or an honours degree.

Since the p-values of both the teachers and the learners taught by teachers that completed different levels of formal education was less than 0.05 respectively, it was concluded that the different levels of formal education were completed with unequal probability and that learners were in classes with teachers that completed different educational levels with unequal probability.

Table 16: Highest level of formal education completed

	Number of teachers that completed each level	Percent	Number of learners taught by teachers that completed each level	Percent
Passed Grade 12	4	1.4	201	1.9
Obtained a post-matric certificate	2	0.7	98	0.9
Obtained a diploma	106	37.2	4 045	38.4
Obtained a first degree	119	41.8	4 317	40.9
Obtained an honours degree+	54	18.9	1 882	17.9
Total	**285**	**100.0**	**10 543**	**100.0**
Chi-square p-value	**0.000*** **		**0.000*** **	

2.4 Mathematics as major area of study

From the 294 responses on the question regarding major areas of study, 233 (79.3%) indicated that mathematics was one of their major study areas. A summary containing the number of teachers with mathematics as major area of study, can be found in Table 17.

The null hypothesis was rejected since the p-values of both the teachers and the learners taught by teachers with mathematics as major area of study, were 0.000*** respectively. It meant that the probabilities of teachers majoring in mathematics and those not majoring in mathematics were unequal.

Table 17: Teachers with mathematics as major area of study

	Number of teachers with mathematics as major area of study	Percent	Number of learners taught by teachers with mathematics as major area of study	Percent
Yes	233	79.3	8 783	80.1
No	61	20.7	2 177	19.9
Total	**294**	**100.0**	**10 960**	**100.0**
Chi-square p-value	**0.000*** **		**0.000*** **	

2.5 Education-Mathematics as major area of study

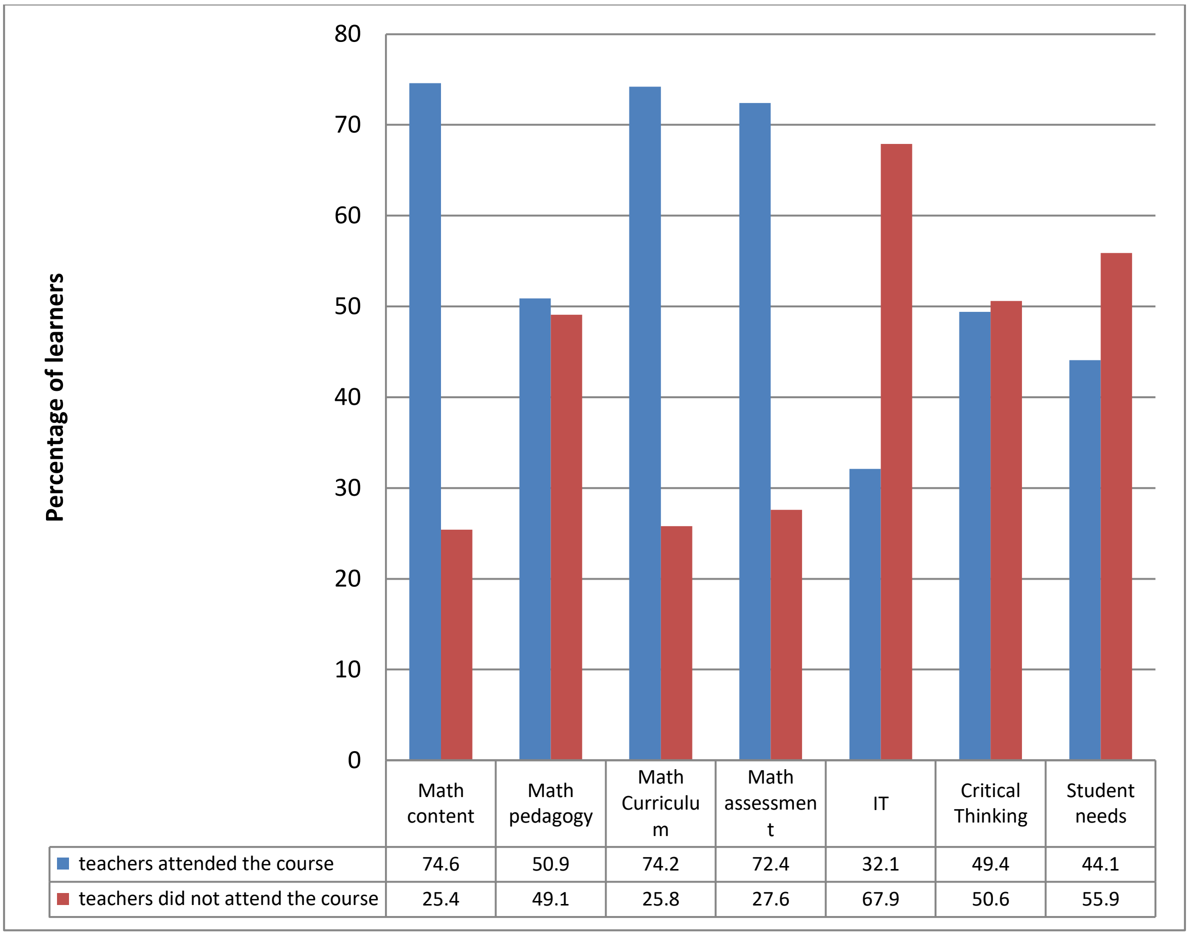
The data in Table 18 shows that only 38.8% of the mathematics teachers had education-mathematics as major area of study. Since the p-value = 0.000*** (< 0.05), the teachers had educational-mathematics as major area of study with unequal probability.

Table 18: Teachers with education-mathematics as major area of study

	Number of teachers with education-mathematics as major area of study	Percent	Number of learners taught by teachers with education-mathematics as major area of study	Percent
Yes	111	38.3	4 195	38.8
No	179	61.7	6 617	61.2
Total	**290**	**100.0**	**10 812**	**100.0**
Chi-square p-value	**0.000*** **		**0.000*** **	

2.6 Professional development courses attended

Teachers were asked if they attended professional development courses in the past two years. Seven fields were identified: Math content, Math pedagogy, Math curriculum, IT, Critical thinking, Math assessment and Student needs. The different fields of professional development identified in the questionnaire and the teachers' responses (reported as a percentage of the learners in their classes) regarding their attendance of such courses, are captured in Figure 8.



	Math content	Math pedagogy	Math Curriculum	Math assessment	IT	Critical Thinking	Student needs
teachers attended the course	74.6	50.9	74.2	72.4	32.1	49.4	44.1
teachers did not attend the course	25.4	49.1	25.8	27.6	67.9	50.6	55.9

Figure 8: Professional development courses' attendance

From the information presented in Figure 8 it seems as if the teachers preferred to attend courses regarding the subject, mathematics, above courses that are aimed at IT, critical thinking development and student needs.

2.7 Years of teaching experience

More than half of the learners (52.2%, as presented in Table 19) were taught by teachers with less than 15 years of teaching experience. Only 27.8% of the teachers in the sample had been in the teaching profession for more than 20 years.

Table 19: Years been teaching

	Number of teachers in each category	Percent	Number of learners taught by teachers in each category	Percent
<10	113	38.8	4 201	38.6
10-14	41	14.1	1 483	13.6
15-19	56	19.2	2 167	19.9
20-24	46	15.8	1 689	15.5
25-29	18	6.2	656	6
30-34	10	3.4	422	3.9
35-39	5	1.7	200	1.8
40-44	2	0.7	70	0.6
Total	**291**	**100.0**	**10 995**	**100.0**
Chi-square p-value	**0.000*** **		**0.000*** **	

The teachers and learners taught by teachers in each category listed in Table 19, were not of equal probability in each category since the p-values were equal to 0.000*** (< 0.05), respectively.

2.8 Overview of teacher characteristics

The majority (64.2%) of the teachers involved in the study ranged between 30 and 49 years of age (seen in Table 15). The difference between the number of male and female teachers were not statistical significant (p-value=0.203). In terms of gender, 46.3% (138 of 298) of the teachers were females and 53.7% (160 of 298) male (seen in Table 14).

The teachers involved in the study reported to have between one and forty-three years of experience. Twenty of the teachers had three years of experience, the average years of experience was 13.93 (seen in Table 19).

The educational level of the teachers involved ranged between 1.4% (4 of 285) that only passed Grade 12 and on the opposite end of the scale 18.9% (54 of 285) that obtained an honours degree. The majority, 79% (225 of 285) of the teachers reported to have obtained a diploma or first degree (see Table 16). Although the teachers reported to have different major areas of study, 79.3% (233 of 294) had mathematics as major area of study (see Table 17). Education-mathematics was only indicated as major area of study in 38.3% of the cases (see Table 18). Teachers attended professional development courses especially regarding math content (74.6% of learners' teachers) math curriculum (74.2% of the learners' teachers) and also math assessment (72.4% of the learners' teachers) (see Figure 8).

3 Teaching qualifications vs Learner performance

The question whether a teacher's qualifications influenced learners' mathematics performance, was investigated in this section. A summary of the number of learners that were taught by teachers in each of the different "level of formal education completed" categories together with the learners' mathematics performance mean (mnpv) and the standard error (sdpv) of the plausible values (pv's), can be found in Table 20.

Table 20: Number of learners, mean and standard error of pv's taught by teachers in each category of level of formal education

Gen\level of formal education completed		Mean of plausible values	Standard error of plausible values
	N	mnpv	sdpv
Finished Grade 12	201	381.76	78.70
Finished post-matric certificate	98	330.69	59.75
Finished diploma	4 045	340.62	79.71
Finished first degree	4 317	359.24	91.95
Finished honours degree or higher	1 882	361.95	89.62
Total	10 543		

3.1 Analysis of level of education vs learner performance

The mean of the mathematics performance mark, based on pv's, of the learners in classes taught by teachers with different levels of formal education completed, is illustrated in Figure 9. Surprisingly, the mean mathematics performance mark of the learners whose teachers have only finished Grade 12 is the highest. It is interesting to notice the upwards trend in the marks when focusing only on the other categories (finished post-matric certificate up to finished honours degree or higher).

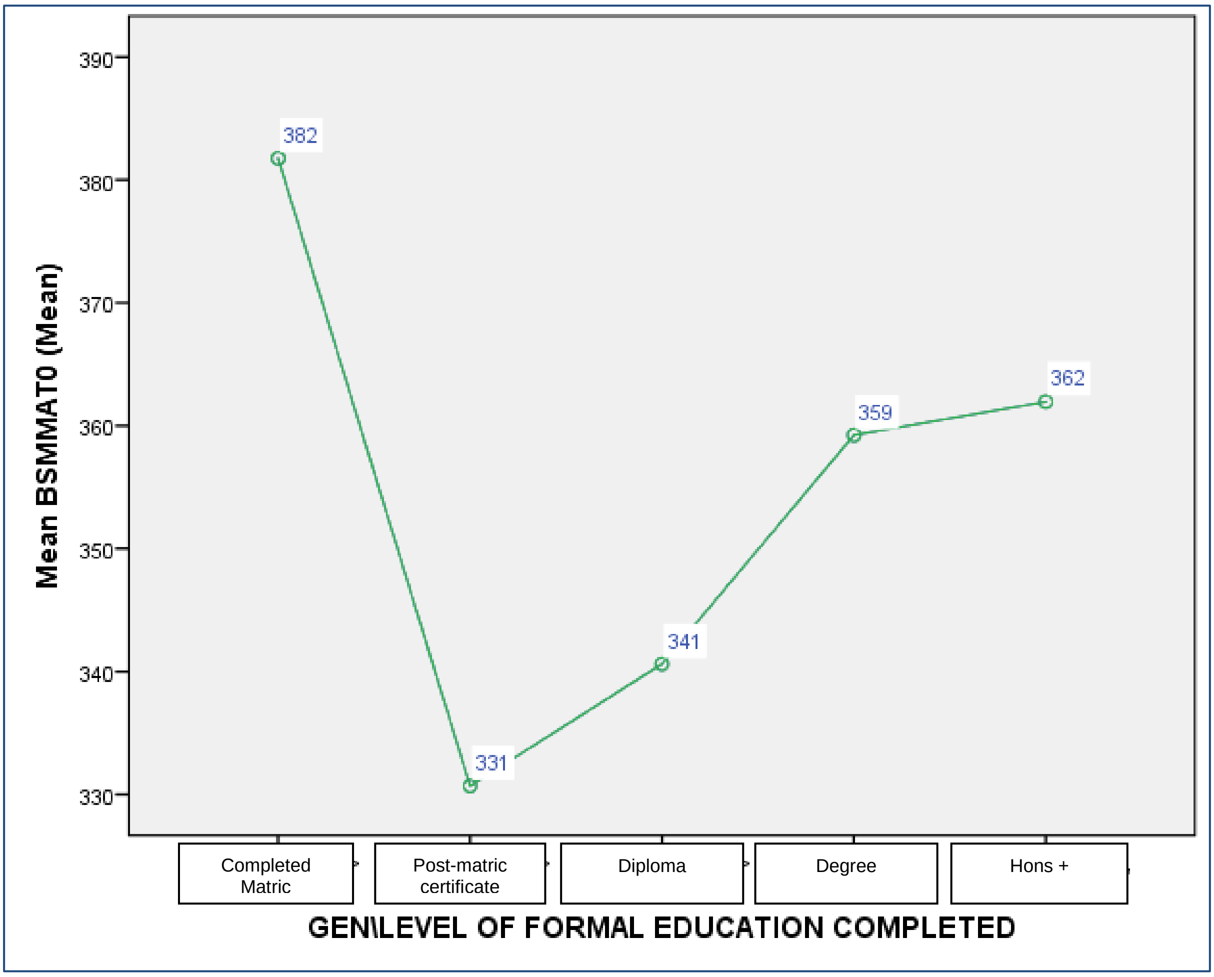


Figure 9: Level of formal education vs mean of the Mathematics performance mark based on pv's

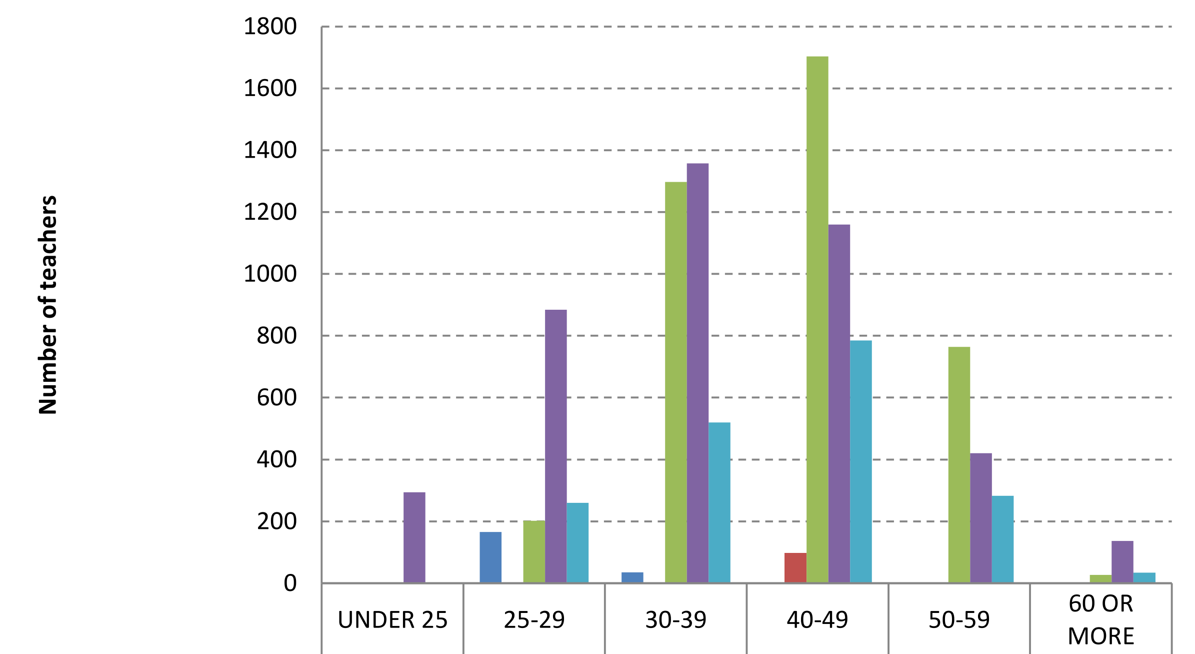
Statistical tests were performed to establish whether the means of the marks achieved by learners whose teachers have completed different levels of formal education, were significantly different from the mean performance achieved by the group of learners that participated in TIMSS 2011. The grand mean, the estimated grand mean regardless of the group "Level of formal education completed" the learners belong to, is 354.85, with a standard error of 7.41. Since one of the levels of formal education completed was used as reference category, the linear regression analysis was run for a second time with a different reference category in order to obtain all of the regression coefficients. The results are summarized in Table 21.

Table 21: Significance in performance of learners taught by teachers with different levels of formal education

		Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		354.85	7.41	47.86
BTBG04_E1	Matric	26.91	28.29	0.95
BTBG04_E2	Post-matric certificate	-24.16	9.86	-2.45***
BTBG04_E3	Diploma	-14.24	9.74	-1.46*
BTBG04_E4	First degree	4.39	8.73	0.50
BTBG04_E5	Hons+	7.10	10.56	0.67

The rows in Table 21 (from BTBG04_E1 to BTBG04_E5) correspond to the estimates for all five of the effect-coded categories of the variable BTBG04. The regression coefficient represents the difference between the mean of each group and the grand mean. The only significant difference, at a 5% level of significance, with the grand mean is with teachers that have obtained a post-matric certificate (BTBG04_E2), since the absolute t-test value is larger than 1.96 (the absolute t-test value is 2.45). Learners whose teachers have obtained only a post-matric certificate perform 24.16 below the grand mean performance. On a 20% level of significance there is a significant difference with teachers that have obtained a diploma (BTBG04_E3), since the absolute t-test value is larger than 1.28 (the absolute t-test value is 1.46). This can be an indication that better qualified teachers will enhance the performance of their mathematics learners. Furthermore, it could be an indication that the mathematics teaching offered in post-graduate certificate and diploma courses differs from that offered in degree courses.

The fact that learners in classes taught by teachers with only matric achieved the highest mean mathematics mark is baffling. Could the age of the teachers involved be an indication as to why matric seems to be the best qualification to have to elicit higher performance? A comparison of age versus qualifications can be found in Figure 10.



	UNDER 25	25-29	30-39	40-49	50-59	60 OR MORE
Matric	0	166	35	0	0	0
Post-Matric certificate	0	0	0	98	0	0
Diploma	0	202	1297	1703	764	27
First Degree	294	884	1357	1160	420	137
Hons+	0	260	520	785	283	34

Figure 10: Age vs Teacher qualification

The majority of teachers who have only completed matric, ranged between 25 and 39 years old; 82.5% of whom were between the ages of 25 and 29. These teachers (in the age category 25 to 29) matriculated between 2004 and 2008, in a period just after considerable educational reform in South Africa. In a document aimed to elaborate on the accomplishments regarding the educational system in South Africa, it is stated that the government intended to establish a system of education that would meet the economic and social challenges of the 21 century. They further elaborated by stating that the qualifications of educators were improved from 36% teachers being under-qualified in 1994 to only 26% in 1998 (Department of Education, 2001). This success story is evident from the information in Figure 10 that indicates that only 299 out of a total of about 11 000 learners were taught by teachers with only matric or a post-matric certificate. The worst mean mathematics mark was scored by learners in classes with teachers that have only a post-matric certificate, they scored 24.16 marks below the grand mean of 354.85.

Another factor that could be in play regarding learner performance is the number of students in each class. From Figure 11 it can be seen that teachers that passed Grade 12 had on average 50 learners in a class. There are 49 learners in a class with teachers that have obtained a post-matric certificate, 38 learners when the teacher has obtained a diploma, 36 for first degree and 35 for an honours degree and higher.

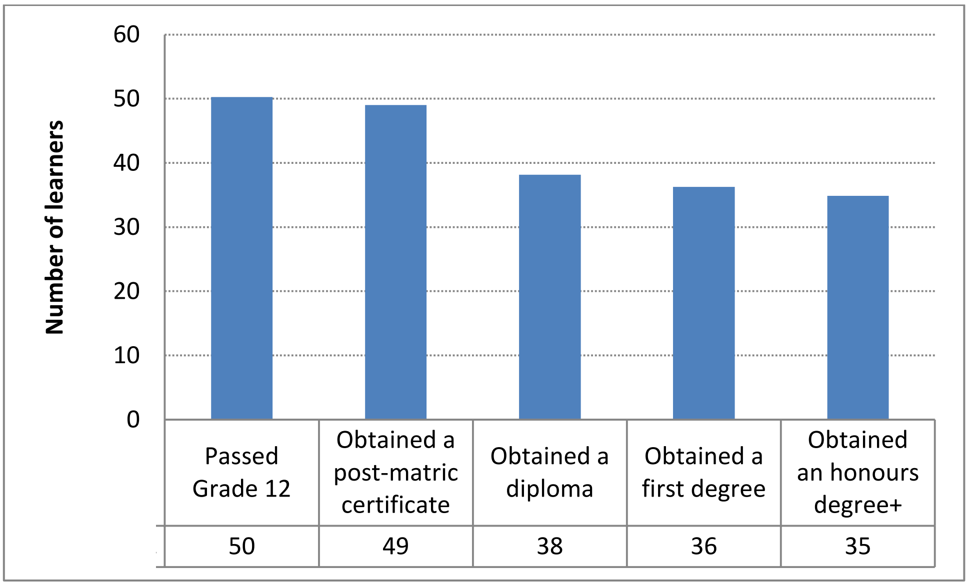


Figure 11: Class sizes

The decrease in the number of learners per class as the education level of the teacher increases, raises the question if it is only the qualification that plays a role? If a teacher has more learners to tend to, other factors such as discipline and even the ability to tend to all of the learners' questions could also have an influence on the learner performance. Could the number of learners also be an indication of the demographic area of the school? The areas with higher population may be of lower income and therefore a teacher with a lower level of educational level becomes more probable?

And why are the results of teachers with matric even higher than those of teachers with an honours degree? Could it be that that the parents or community were more involved? Or did the teachers themselves being under qualified, put in a bigger effort because they experienced the pressure for the learners to perform even more than other teachers? Or is it possible that the learners felt more connected to these teachers or that the teachers understood them better, being closer to the same level of education? Further studies are necessary to shed light on these issues.

When considering the fact that only four teachers in the sample of 285 teachers had only achieved matric and only another two teachers had a post-matric certificate, no valid deductions can be made regarding the fact that their learners obtained the highest and lowest median average mathematics scores respectively.

The decrease in number of teachers that have completed a diploma is most possibly also a result of policy reform in 1994 (Department of Education, 2001). When considering the number of teachers with diplomas, it is interesting to note that this qualification was predominant for teachers between the ages of 40 and 59 (45.5% of learners taught by teachers with diploma, 31% by teachers with degree). In the age category 30 and 39, however 40.4% of the learners were taught by teachers with a diploma in contrast with the 42.3% of learners taught by teachers that have obtained a degree. There was a significant decline in numbers of teachers with diplomas in the 25 to 29 year category (only 13% of learners taught by teachers with a diploma vs 58.8% taught by teachers with a degree).

Training of teachers in South Africa before and during the transitional period in the years following 1994, was predominantly done at colleges that were administered by provincial administrations and by various “separate development” political structures (Gordon, 2009). Since curriculum and examinations were controlled by various stakeholders, the quality of the education of teachers differed. Gordon (2009) also stated that "many teacher education colleges for African student teachers operated essentially as secondary schools rather than as tertiary institutions" (Gordon, 2009, p. 14). This fact is disturbing when considering the responses on the question regarding highest level of education. Teachers might indicate that they have achieved a diploma. However, since no information regarding the institution where the teacher has studied is available, the information may be flawed since the quality of education might differ between the respondents. Teachers could also study at a higher education institution and complete a three-year degree (e.g.BA or BSc) as a prerequisite for a Post Graduate Certificate in Education (PGCE), previously known as a higher education diploma (HED). Since this qualification is only accessible after obtaining a degree, there might be confusion regarding the highest level of education completed, the degree or the diploma.

To be able to interpret the results of the learners with teachers that have obtained a diploma, the context of teacher education in South Africa should be taken into account. The age of the teacher might give an indication of the era in which the teacher has graduated, but this might also not be accurate since no information regarding the starting date of his or her study is available.

The difference between the performances of learners in classes where the teacher had a diploma, versus those where the teacher had a first degree, is significant. Even though the applied and hands-on approach followed by teacher training colleges is widely appraised (Chisholm, 2009), learners in a class with a teacher that obtained a first degree, outperformed their counterparts where the teacher had only completed a diploma. Could it maybe result from the fact that teachers who have obtained a degree had exposure to mathematics as major area of study as opposed to teachers with only a diploma?

3.2 Analysis of major areas of study vs learner performance

Teachers were also asked to specify their major area of study. Two major areas of study were of interest: either mathematics or education mathematics as major area of study. The difference in the mean mathematics performance marks, based on pv's, can be seen in Figure 12 for mathematics as major and for education mathematics as major in Figure 13. Learners in classes with teachers with mathematics as major have a lower mean mathematics performance mark than those whose teachers indicated that they did not have mathematics as major area of study. Could it be that teachers, who chose to study mathematics, were so proficient in the subject, mathematics, that they could not understand the problems that the learners were facing?

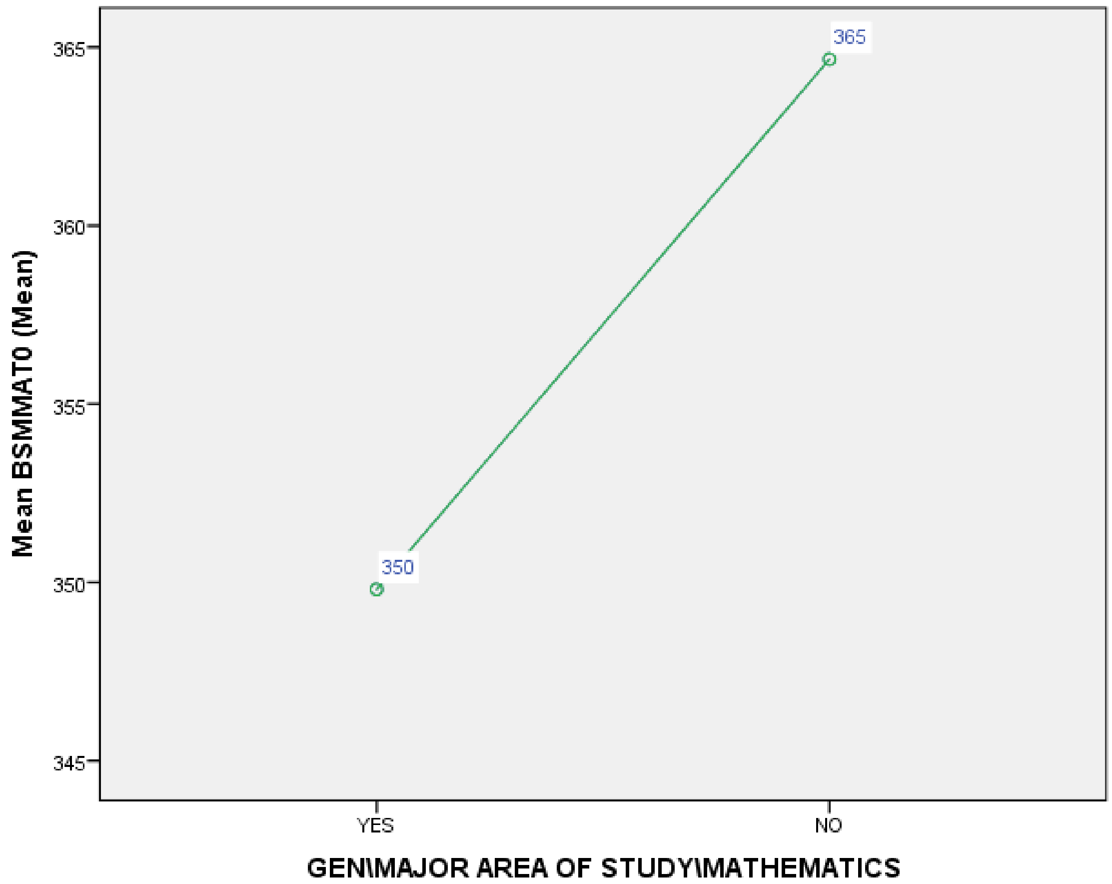


Figure 12: Mathematics as major vs average mathematics performance

The difference in the mean mathematics performance marks of students whose teachers had or did not have mathematics as major area of study, is 14.86. The difference is not significant as the absolute t-value is 1.18 as can be seen in Table 22.

Table 22: Significance in performance of learners taught by teachers with mathematics as major area of study

		Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		364.66	10.85	33.62
BTBG05A_D1	Mathematics as major	-14.86	12.61	-1.18

In contrast with the above-mentioned, learners whose teachers had education mathematics as major area of study outperformed learners whose teachers did not have education mathematics as major area of study (see Figure 13).

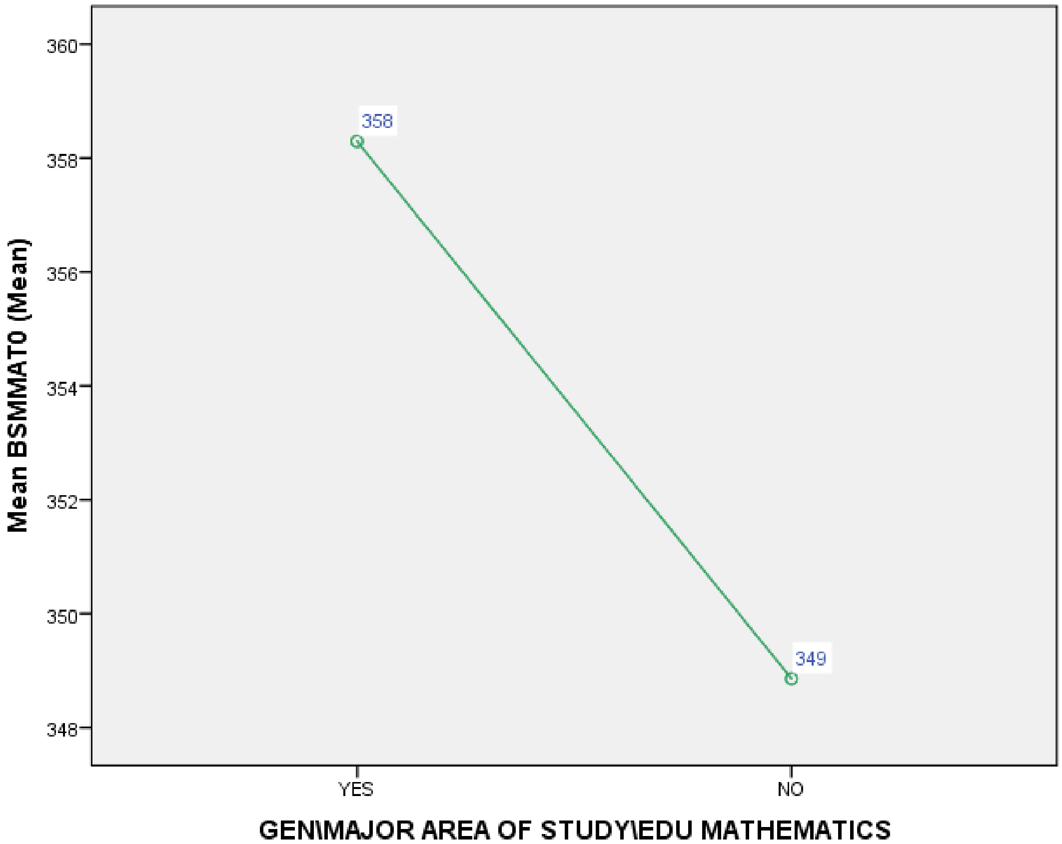


Figure 13: Education mathematics as major vs average mathematics performance

Learners whose teachers had education mathematics as major area of study performed on average 9.44 marks better than their counterparts. Since the absolute value of the t-test is 1.04, the difference in the mean mathematics marks is not significant (see Table 23).

Table 23: Significance in performance of learners taught by teachers with education mathematics as major area of study

		Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		348.86	4.10	85.14
BTBG05F_D1	Education Mathematics as major	9.44	9.10	1.04

The number of learners, whose teachers have mathematics as major area of study in the different levels of formal education achieved, is tabulated in Table 24. It seems as if the majority of the learners' teachers (8 258 of 10 435 learners) indicated that they had mathematics as major area of study.

Table 24: Level of Education vs Mathematics as major area of study

	Major area of study: Mathematics		**Total**
	Yes	**No**	
Matric	165	36	201
Post-matric certificate	98	0	98
Diploma	3 105	904	4 009
First degree	3 363	915	4 278
Hons+	1 527	322	1 849
Total	8 258	2 177	10 435

The data displayed in Table 25 shows that only about 40% of the learners were taught by teachers with education mathematics as major area of study. The fact that the teachers that have only matric indicated in Table 24 that they had mathematics as major (only 36 learners not taught by a teacher that did not have mathematics as major) and in Table 25 that they also have education mathematics as major (again only 43 learners), raise the question whether they understood the difference between the subjects mathematics and education mathematics. Another interesting observation is that all of the teachers with a post-matric certificate indicated that they had mathematics as major area of study.

Table 25: Level of Education vs Education Mathematics as major area of study

	Major area of study: Education Mathematics		Total
	Yes	No	
Matric	158	43	201
Post-matric certificate	0	98	98
Diploma	1 476	2 469	3 945
First degree	1 685	2 548	4 233
Hons+	711	1 099	1 810
Total	4 030	6 257	10 287

It is evident from the data in Table 24 and Table 25 that the difference between the major areas of study of learners' teachers is similar between teachers with diplomas (3 105 for mathematics and 1 476 for education mathematics) and teachers with degrees (3 363 for mathematics and 1 685 for education mathematics).

3.3 Analysis of educational level and major areas of study vs learner performance

The effect of teachers with mathematics as major area of study across the different levels of formal education achieved on the mathematics performance of learners is tabulated in **Error! Reference source not found.**.

The regression coefficient indicates that learners whose teachers have a diploma without mathematics as major area of study, achieved on average 53 marks less (a significant difference according to the results of the t-value test) than the mean performance of the group. Even with a major in mathematics, their learners were 7 marks below the average performance of the group (this is however not indicated as a significant difference). There was also a significant difference (absolute t-value = 2.26) in the performance of learners whose teachers only have a post-matric degree.

Table 26: Learner results of teachers with mathematics as major area of study vs level of education

BTBG05A			**Regression coefficient**	**Regression coefficient (standard error)**	**Regression coefficient (t-value)**
	EqVar	**Label**	**b**	**b.se**	**b.t**
No	**(CONSTANT)**		**389.62**	**13.92**	**28.00**
No	BTBG04_E1	Matric	73.42	#NULL!	#NULL!
No	BTBG04_E3	Diploma	-53.03	18.62	-2.85***
No	BTBG04_E4	Degree	-15.83	#NULL!	#NULL!
No	BTBG04_E5	Hons+	-4.56	22.22	-0.21
Yes	**(CONSTANT)**		**348.59**	**4.43**	**78.64**
Yes	BTBG04_E1	Matric	7.92	14.63	0.54
Yes	BTBG04_E2	Post-matric certificate	-17.90	7.91	-2.26***
Yes	BTBG04_E3	Diploma	-7.08	8.17	-0.87
Yes	BTBG04_E4	Degree	7.29	6.60	1.11
Yes	BTBG04_E5	Hons+	9.76	9.20	1.06

#NULL – not enough data available for calculations

The effect of teachers with education mathematics as major area of study across the different levels of formal education achieved on the mathematics performance of learners is presented in Table 27.

Table 27: Learner results of teachers with education mathematics as major area of study vs level of education

BTBG05F			Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
	EqVar	**Label**	**b**	**b.se**	**b.t**
No	**(CONSTANT)**		**340.47**	**3.46**	**98.39**
No	BTBG04_E1	Matric	-16.45	#NULL!	#NULL!
No	BTBG04_E2	Post-matric certificate	-9.78	7.70	-1.27
No	BTBG04_E3	Diploma	-0.21	#NULL!	#NULL!
No	BTBG04_E4	Degree	18.39	6.81	2.70***
No	BTBG04_E5	Hons+	8.05	8.90	0.90
Yes	**(CONSTANT)**		**370.92**	**12.07**	**30.74**
Yes	BTBG04_E1	Matric	23.73	45.30	0.52
Yes	BTBG04_E2	Post-matric certificate	#NULL!	#NULL!	#NULL!
Yes	BTBG04_E3	Diploma	-30.53	13.62	-2.24***
Yes	BTBG04_E4	Degree	-11.65	#NULL!	#NULL!
Yes	BTBG04_E5	Hons+	18.45	17.96	1.03

#NULL – not enough data available for calculations

The t-test value of 2.7 indicates that learners in classes where a teacher has a degree but did not have education mathematics as major area of study, performed significantly better than the grand mean of the group (18.39 points better). There is also a significant difference between the performance of learners in classes where a teacher has a diploma and education mathematics as major area of study and the grand mean of the group of learners. The difference is reflected in Table 27 showing that learners perform 30.53 marks less than the grand mean for other learners. This is contrary to the expectation that teachers with a diploma and education mathematics as major area of study will have a positive influence on the performance of the learners.

When considering the major area of study, the responses of the teachers might be flawed. The question is: When is a subject considered to be a major area of study? The confusion is already evident from the responses of the teachers that have completed only matric. They have indicated to have mathematics and education mathematics as major area of study (see Table 28).

Table 28: Major areas of study

Level of formal education completed	Major area of study: Mathematics		Total	Major area of study: Education Mathematics		Total
	YES	NO		YES	NO	
Completed matric	3	1	4	3	1	4
Post-Matric certificate	2	0	2	0	2	2
Diploma	81	24	105	36	67	103
Degree	93	25	118	47	70	117
Hons+	42	11	53	22	30	52
Total	221	61	282	108	170	278

Even when considering the responses of teachers that have obtained a diploma, careful consideration is needed. Is the mathematics qualification of a teacher that has trained at a teacher college with mathematics as a subject over the four years of study equal to education mathematics on a final year level at the university? This question raises alarm regarding how the teachers interpreted the questions and it is also debatable whether they really have insight in the differences between mathematics as major and education mathematics as major. When considering the responses on the above mentioned items, the confusion can also be seen with teachers that have obtained a diploma in South Africa. Some of them indicated that they had education mathematics as major (36 of 103) and 81 of the 105 teachers that have obtained diplomas believe that they had mathematics as a major area of study. The teachers that have obtained a post-matric certificate, although having the worst learner mathematics results, only indicated mathematics as major area of study.

From the above-mentioned it is clear that the educational level and the major area of study indicated by the teachers could differ depending on the institution where the teaching qualification was obtained and the era in which the teacher studied.

4 Teaching experience vs Learner performance

The question whether teaching experience, measured in number of years, influenced a learner's mathematics performance, was investigated in this section. Teaching experience (in this study) ranges between one year and 43 years. There are numerous theories (e.g. Katz, Huberman, Day, Fuller, Fessler as discussed in Chapter 2) surrounding the development stages of teachers. This section reports on the different stages (development stages) proposed by Katz (1972) (only four stages), Huberman (as described in Joerger, 2010) (five stages) and Day (2006) (six stages). The mathematics performance of learners is thereafter explored and compared with the years of teaching experience of the teacher.

4.1 Development stages proposed by Katz

The development stages for preschool teachers proposed by Katz are survival, consolidation, renewal and maturity (Katz, 1972). These stages correspond with Dreyfus' developmental stages for adult skill acquisition from novice to expert (Dreyfus S. , 2004). Benner adjusted the stages proposed by Dreyfus to accommodate the development of nurses (Benner, Tanner, & Chesla, 2009). As such, the use of these development stages seems to be appropriate in the investigation of the relationship between the teaching experience and the mathematics performance of learners. The duration of each of the developmental stages may differ for teachers but for the purpose of this study, year 1 acts as the survival stage. Year 2 is considered to be the stage of consolidation, the renewal stage is between year 3 and 4 and the final stage 'maturity' from year 5 onwards. A summary of the number of learners that were taught by teachers in each of the different teacher development stages as proposed by Katz, together with the learners' mathematics performance mean (mnpv) and the standard error (sdpv) of the plausible values (pv's), can be found in Table 29.

Table 29: Number of learners, mean and se of pv's taught by teachers in each category of teacher development

		Mean of plausible values	Standard error of plausible values
	N	mnpv	sdpv
Survival (Year 1)	319	366.20	83.20
Consolidation (Year 2)	466	328.91	90.77
Renewal (Year 3-4)	1 264	345.49	86.00
Maturity (Year 5+)	8 839	354.11	86.50
Total	10 888		

The differences between the mathematics performances of learners in classes taught by teachers with differing numbers of years' experience can be seen in Figure 14. Surprisingly, learners in classes with teachers who have only one-year experience outperform the whole spectra of learners. The difference in the average mathematics mark between year one and two confirm the statement regarding the decline of teachers' self-efficacy (in the period between teacher training, at the end of their practicum experiences and the end of their first year of teaching) as a result of "a reality shock at the end of Year 1 of experience in the classroom" (Klassen, 2014, p. 103).

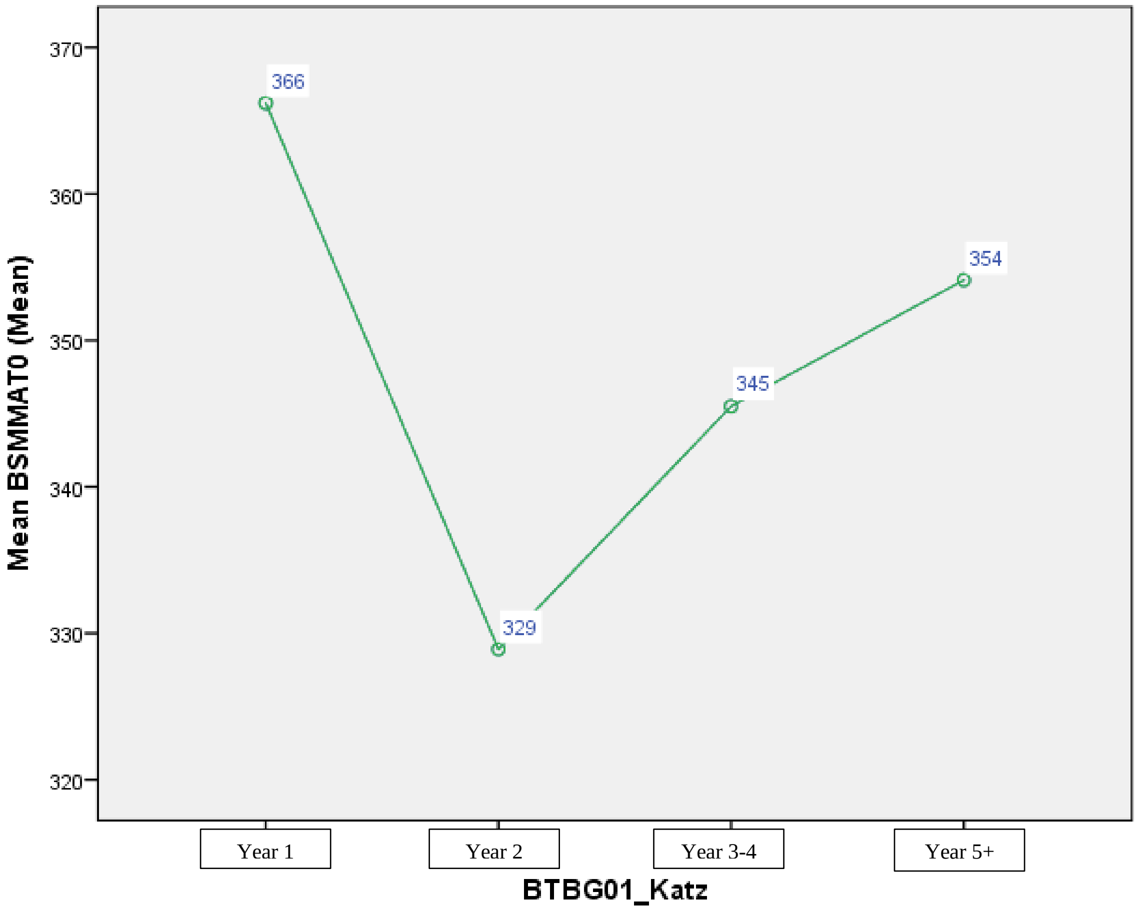


Figure 14: Teacher development stages proposed by Katz vs mathematics performance

There is no significant difference between the grand mean of the learners' mathematics mark and any of the teacher development stages as proposed by Katz. The output from the linear regression analysis with effect coding is given in Table 30.

Since the average number of years' experience of the TIMSS data set was approximately 14 years, the question arises whether the binning proposed by Katz revealed all of the information regarding the influence of teaching experience on the mathematics performance of learners in the last stage of 5 years+. After 10 years, one would intuitively expect the effect of the teacher's experience on the performance of learners to remain constant. The other theories regarding the development stages of teachers also need to be considered to comprehend the influence of teaching experience on mathematics performance.

Table 30: Significance in performance of learners taught by teachers in Katz' development stages

		Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		348.68	8.26	42.23
BTBG01_E1	1 year	17.52	18.81	0.93
BTBG01_E2	2 years	-19.77	17.82	-1.11
BTBG01_E3	3-4 years	-3.18	10.54	-0.30
BTBG01_E4	5+ years	5.43	9.73	0.56

4.2 Development stages proposed by Huberman

According to Huberman (1989), teachers experience five development stages in their careers as teachers. The first stage is called "Survival and Discovery" and ranges from one to three years of experience. The second stage (stabilisation), between years four and six is followed by a stage of experimentation/diversification (seven to 18 years of experience). Teachers do stock-taking and interrogations in this stage that lead to conservatism or serenity, the theme for the next stage (19-30 years of experience). From year 31 to 40, teachers start to disengage with the profession, either serene or bitter. The data was binned, by using SPSS, in the proposed categories and the last stage was extended to include teachers up to 43 years of experience, since the TIMSS data ranged up to 43 years of experience.

A summary of the number of learners that were taught by teachers in each of the different teacher development categories as proposed by Huberman, together with the learners' mathematics performance mean (mnpv) and the standard error (sdpv) of the plausible values (pv's), can be found in Table 31.

Table 31: Number of learners, mean and se of pv's taught by teachers in each category of teacher development

		Mean of plausible values	Standard error of plausible values
	N	mnpv	sdpv
Survival and Discovery (1-3)	1 458	343.03	87.71
Stabilization (4-6)	1 515	353.60	85.35
Experimentation/Diversification (7-18)	4 397	362.33	89.43
Conservatism/Serenity (19-30)	3 111	341.83	83.74
Disengagement (31-43)	407	362.71	73.38
Total	10 888		

The mean mathematics performance of the learners is plotted in Figure 15 according to the different teacher development stages as proposed by Huberman. The mean performance score is, as expected, increasing from a low value of 343 to a value of 362 in the first three stages. Surprisingly, the mean dropped when teachers have between 19 and 31 years of experience to the lowest mean value of 342 after which the highest value of 363 is achieved when teachers have between 31 and 43 years of experience.

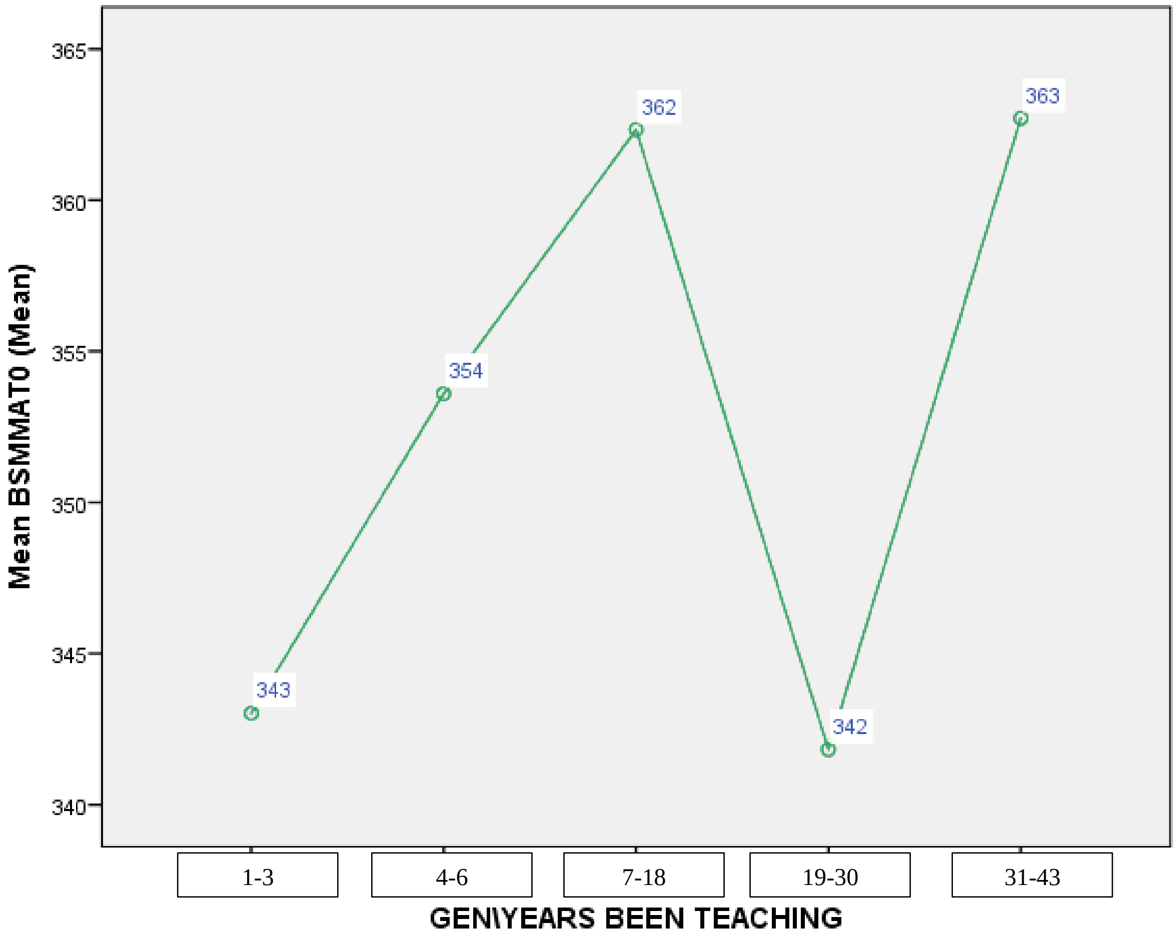


Figure 15: Huberman's stages of teacher development vs mathematics performance

There are no 5% or 10 % significant differences between the grand mean of mathematics performance and any of the teacher development stages as proposed by Huberman. The mean mathematics mark was 9.6 marks above the grand mean for 7 to 18 years teaching experience (at a 20% level of significance) and also 10.9 marks below the grand mean for 19 to 30 years teaching experience, also on a 20% level of significance. The output from the linear regression analysis with effect coding is given in Table 32.

Table 32: Significance in performance of learners taught by teachers in Huberman's development stages

		Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		352.70	3.99	88.49
BTBG01_E1	1-3 years	-9.67	10.38	-0.93
BTBG01_E2	4-6 years	0.90	7.84	0.12
BTBG01_E3	7-18 years	9.63	7.53	1.28*
BTBG01_E4	19-30 years	-10.87	7.36	-1.48*
BTBG01_E5	31-43 years	10.01	13.23	0.76

The difference between the mean mathematics performance of the last two stages of teacher development according to Huberman, (from 342 to 363) raises another question regarding the time span of 19 to 43 years, and therefore another theory regarding the developmental stages of teachers were also investigated.

4.3 Development stages proposed by Day

Day (1999) stated that professional development could not be seen as a "linear continuum" (Day, 1999, p. 68). Proposed teacher development stages focus on the "teacher as employee" and not on the "teacher as a person" (Day, 1999, p. 68). The teacher has to be considered as a holistic entity. Every teacher has a different history, works in different organisational contexts and cultures and furthermore experience different phases of cognitive and emotional development. He proposed six stages of teacher development: Commitment (support and challenge, 0-3), Identity and Efficacy in Classroom (4-7), Managing Changes in Role and Identity, Growing Tensions and Transitions (8-15), Work-life Tensions, Challenges to Motivation and Commitment (16-23), Challenges to Sustaining Motivation (24-30) and Sustaining/Declining Motivation, Ability to cope with Change, Looking to Retire (31+).

A summary of the number of learners that were taught by teachers in each of the different teacher development categories as proposed by Day, together with the learners' mathematics performance mean (mnpv) and the standard error (sdpv) of the plausible values (pv's), can be found in Table 33.

Table 33: Number of learners, mean and se of pv's taught by teachers in each category of teacher development

		Mean of plausible values	Standard error of plausible values
	N	mnpv	sdpv
Commitment, support and challenge (0-3)	1 458	343.03	87.71
Identity and Efficacy in Classroom (4-7)	1 820	354.37	86.18
Managing Changes in Role and Identity, growing tensions and transitions (8-15)	2 786	366.57	87.87
Work-life Tensions, challenges to motivation and commitment (16-23)	3 132	348.44	88.50
Challenges to Sustaining Motivation (24-30)	1 256	335.70	79.40
Ability to cope with Change, Looking to Retire (31+)	436	363.84	73.07
Total	10 888		

Once again the mean mathematics performance mark increased in the first 15 years of teaching experience after which started to decrease over the next seven years of experience. The mean mathematics mark of learners whose teachers have between 24 and 30 years of experience decreased to a low value of 336. It seems as if teachers in this development stage face challenges to sustain their motivation, as implied by Day (1999). The graph in Figure 16 illustrates the decrease in the mean mathematic performance scores of the learners in classes with teachers that have between 16 and 30 years of experience. Fortunately, the scores increase considerably after this stage.

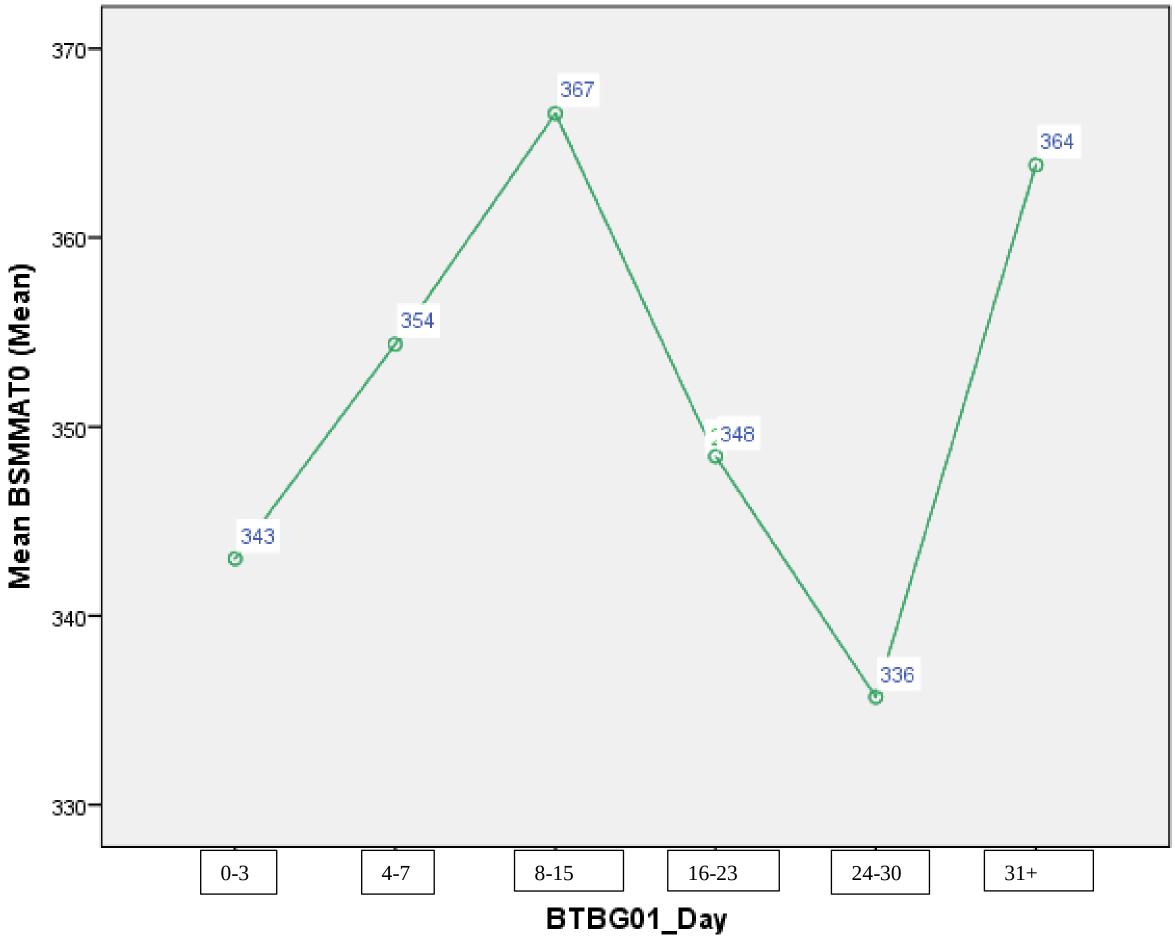


Figure 16: Day's stages of teacher development vs mathematics performance

The mean mathematics performance mark of learners whose teachers have between eight and 15 years of experience is 14.6 marks above the grand mean performance score of all of the learners (at a 10% level of significance). When considering teachers with between 24 and 30 years of experience, the learners have 16 marks below the grand mean of the mathematics performance of all of the learners (also at a 10% level of significance). Table 34 displays a summary of learner performance according to Day's teacher development stages.

Table 34: Significance in performance of learners taught by teachers in Day's development stages

		Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		351.99	3.30	106.81
BTBG01_E1	0-3 years	-8.97	10.73	-0.84
BTBG01_E2	4-7 years	2.38	7.89	0.30
BTBG01_E3	8-15 years	14.58	8.41	1.73**
BTBG01_E4	16-23 years	-3.55	5.82	-0.61
BTBG01_E5	24-30 years	-16.29	9.57	-1.70**
BTBG01_E6	31+ years	11.85	13.47	0.88

Bearing in mind that the mean mathematics marks of learners in the classes of teachers in Huberman's and Day's stages of development show differences depending of the years included or excluded (7 to 18 years, 362 marks and 8 to 15 years, 367 marks), the next analysis was done for every year.

4.4 Learner performance for every years of experience category

The difference in the average mathematics mark between the development stages, raised the question about what happened every year? The original binning was therefore changed and the whole spectrum of teaching experience was plotted instead. The resulting graph, in Figure 17, was even more thought-provoking. The average mathematics mark measured between approximately 320 and 410 until the 26th year of teaching experience after which it peaks at 27 years and again at 44 years of experience. Unexpectedly, even though the highest average mathematics mark was noted at 43 years of experience, the worst average mathematic mark was encountered with teachers with 42 years of experience. The graph in Figure 17 reveals that between years 27 to 43, the average mark was higher than that of the first twelve years in only three year periods.

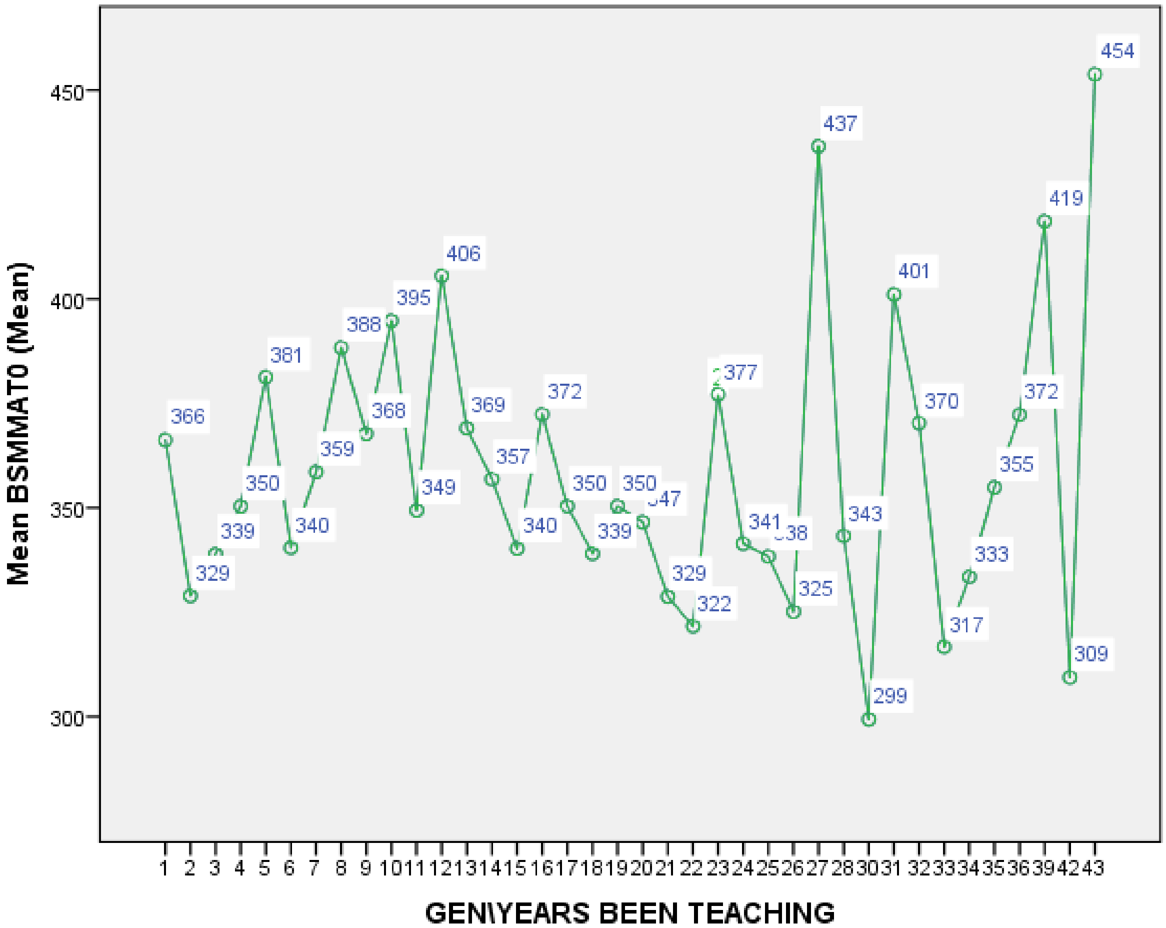


Figure 17: Teaching experience vs average mathematics mark

When considering the first twelve years of teaching, learners had a better average mark in classes with teachers that had five, eight, ten and twelve years of experience. These teachers are, according to Huberman (1989) in the stabilisation stage (four to six years) and in the beginning of the period (7-18 years) of experimentation/activism or even reassessment. This average mark was only improved again by learners whose teachers had 27 years of experience, with the average mark from 12 years of experience up until 26 years, being consistently lower than the mark attained in year 12. Even though Klassen (2014) stated that teachers' self-efficacy builds up from 0 years of experience to reach a maximum at 23 years of experience, this data shows a steady increase of the mean mathematics mark up to year 12 after which the marks varied between 320 and only 380 to reach the second highest mean value (437) in year 27. The fact that the "younger" teachers (teachers with less experience) affect the performance of the learners positively could be the result of the fact that they relate better with the learners as the age gap (assuming that they have joined the teaching profession early in life) between learners and teachers may be smaller than may be the case with the more experienced colleagues (Chisholm, 2009). Another explanation might be that they may be better equipped to teach because of advances in teacher training programs and also that they have a better understanding of the content to be taught.

From year 13 to year 26, the mean mathematics mark varies between 322 and 377. It seems as if the teachers in this age group are not only focused on their careers as teachers. Could it be the result of the teacher's own family life seeing that the teacher is about 38 years old at the stage that he/she has 15 years' experience? Teachers at this age could possibly have children that are also about the age of their learners and this could possibly influence the approach of the teacher in the delivery of his or her classes? The available information does not allow further investigation.

The highest average marks were, in contrast to Klassen's (2014) statement that self-efficacy declines in late career teachers, reached by learners whose teachers had 27 years of experience and also teachers with 43 years of experience. Interesting to note a teacher with 27 years of experience, supposing that he/she started teaching at the age of 23, are about 50 years of age. Similarly, a teacher with 43 years of experience, are approximately 66 years of age. Could the personal environment, especially the life stages of the teacher (mid-life crisis and retirement) as discussed by Fessler and Christensen (1992) be responsible for these phenomena?

From years 27 to 44 there seems to be a huge variation in the marks, from 299 to 454. Is it possible that teachers are more innovative in their teaching methods and that the learners perform according to their own abilities and not because they were trained in specific exam writing strategies? Since the TIMSS data set only contains questions with a few response options or numerical answers, further investigation into these speculations were not possible and can be pursued in a next study.

Three different theories regarding the stages experienced in teacher development were investigated. It is evident from the results that the use of only four categories that groups the years of experience from five years and more together, fails to convey the real status of learner performance through the years after a teacher has five years of teaching experience. Huberman's five stages shed more light on the learner performance of teachers with more than five years' experience but the 20mark difference in the mean performance of the learners between the periods from 7-18 and 19-30 years of experience, shows that even smaller increments are necessary. With Day's categories the stage of the lowest mathematics performance could be identified. Learners in classes with teachers that have between 24 and 30 years of experience have the lowest mean performance scores. The question arises whether this is true globally or only in South African context?

5 Summary of Findings

The findings of the data analysis done in this chapter are summarised in Table 35. Contrary to all expectations, the mean mathematics mark of learners whose teachers have only obtained matric, were the highest. The mean mathematics performance of learners whose teachers had mathematics as major area of study was surprisingly lower than their counterparts.

Table 35: Breakdown of the learners' average mathematics achievement mark by the categories of teacher profile variables

Teacher variables	Number of learners	Group mean	Significance
Qualification			
Matric	201	381.76	
Post-matric certificate	98	330.69	Yes 5%
Diploma	4 045	340.61	Yes 20%
First degree	4 317	359.24	
Hons+	1 882	361.95	
Gap: Diploma and Hons+		**21.34**	
Seniority according to Katz			
Survival (Year 1)	319	366.20	
Consolidation (Year 2)	466	328.91	
Renewal (Year 3-4)	1 264	345.49	
Maturity (Year 5+)	8 839	354.11	
Biggest gap: between year 1 and 2		37.29	
Seniority according to Huberman			
Between 1 and 3years	1 458	343.03	
Between 4 and 6 years	1 515	353.60	
Between 7 and 18 years	4 397	362.33	Yes 20%
Between 19 and 30 years	3 111	341.83	Yes 20%
31+years	407	362.71	
Biggest gap: between 19 and 30 years and 31+ years		20.88	

Teacher variables	Number of learners	Group mean	Significance
Seniority according to Day			
Between 0 and 3years	1 458	343.03	
Between 4 and 7 years	1 820	354.37	
Between 8 and 15 years	2 786	366.57	Yes 10%
Between 16 and 23years	3 132	348.44	Yes 10%
Between 24 and 30 years	1 256	335.70	
31+years	436	363.84	
Biggest gap: between 24 and 30 years and 31+ years		28.14	

In this chapter the results of the data analysis were reported and discussed. The next chapter contains a summary and discussion together with recommendations for further studies and policies.

Chapter 5: Conclusions and Recommendations

1 Introduction

The research conducted for the purpose of this study, revealed a number of interesting findings and raised even more questions regarding the influence of teacher qualifications and years of experience on learner performance. This chapter commences by summarising the research after which the findings are discussed. Recommendations for further studies will conclude this chapter.

2 Summary

The quality of education in South Africa, in particular in subjects such as mathematics and science, is a problem faced by all South African citizens. Evidence from the mathematics results in Grade 9 (Department of Basic Education, 2013) and also in the matric results (Department of Education, 2014) support the impression that urgent measures need to be employed in an effort to salvage this situation.

Mathematics is a core subject that influences all facets of life. Apart from functioning effectively as an individual, proficiency in mathematics also influences success and effectiveness in the workplace (Hodgen & Marks, 2013). It is evident that proficiency in mathematics will therefor influence the economy of the country as it reflects the quality the country's people (Wallace, 2013). Therefore it seems increasingly important to look at the mathematics performance of our learners.

Mathematics performance can be seen as evidence of the learning of mathematics (Zuzovsky, 2009). There are various different viewpoints regarding the goals associated with the learning of mathematics (as discussed in Chapter 2). A learner should be able to think critically and creatively, applying their mathematical knowledge in real life situations. Learner performance is an accurate measure of the effectiveness (Zuzovsky, 2009), of the schooling system, and/or the teacher and/or community involvement and/or the learner.

Various factors could have an influence on learner performance as can be seen in the research topics of numerous studies conducted in this regard (a few of them are listed in Chapter 2). The categorisation of the factors as being school and school related, teacher and teacher related and learner and learner related (Shavelson et al., 1989), provides a structure by which we can analyse these factors. Each of these categories includes numerous factors regarding the physical, personal and emotional dimensions of the participants, and in the case of the school and school related factors, the school resources and the school environment (factors such as safety also come into play). There are numerous learner and learner related factors that could influence mathematics performance. The learner as an individual has his or her own background that includes home environment and resources and parent qualifications and involvement, to name only a few of these factors. The learner brings emotional facets (motivation, confidence, feelings of failure, and more) to the learning environment as well.

Several teacher related factors, discussed in Chapter 2, have an influence on leaner performance. Teacher and teacher related factors include background factors, the teacher's professional profile and even factors concerning motivation, job satisfaction and feelings of confidence or inadequacy. A teacher should be considered as a holistic entity. Each teacher originates from a unique background, and has obtained qualifications that may differ and works in different environments. Apart from these factors, teachers are also in different personal life cycles, whether it is being single, as a member of a family with (most probably) children, as a person in their forties with a possible mid-life crisis, or as a person approaching the end of his or her career. There are numerous theories regarding the development stages of teachers. These development stages include the whole professional life cycle of a teacher.

In South Africa, we need expert teachers as numerous learners originate from low-income households and as such come unprepared to the learning environment. Alas, it is not possible to change factors related to a learner's background and as such the level of the intake of the learners. Fortunately, Hanushek (2002) stated that high-quality teachers could diminish the average performance deficit between low-income kids and others in only three years.

The fact that a teacher, as the ambassador of knowledge, plays an important role in the education of learners, and also that the teacher is deemed to be responsible for the performance of learners (BusinessTech, 2015) in South Africa, led to the following research questions.

- How do the teacher's qualifications and years of teaching experience influence the mathematics achievement scores of the Grade 9 learners in South Africa, who participated in the TIMSS 2011?

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

- What is the general profile of the teachers who participated in TIMSS 2011?
- What were the influence of teacher qualifications and the years of teaching experience, on the mathematics achievement scores of the Grade 9 learners of South Africa, who participated in TIMSS 2011?
- Which of the above-mentioned teacher credentials had a significant influence on the mathematics achievement scores of the Grade 9 learners of South Africa, who participated in TIMSS 2011?

A summary of the general profile of the teachers that participated in TIMSS 2011 is presented in Table 36. Since the information provided describes the teacher profile, the percentages report the percentage of teachers and not the percentage of learners that were subjected to teachers in each category.

Table 36: Profile of the teachers who participated in TIMSS 2011

	Categories	**% of teachers**
Age (See Chapter 4 Table 15)	Between 30 and 40	64.2%
Gender (See Chapter 4 Table 14)	Male Female	53.7% 46.3%
Educational level (See Chapter 4 Table 16)	Matric Diploma or first degree Honours degree	1.4% 79% 18.9%
Major area of study (See Chapter 4 Table 17 & 18)	Mathematics Education Mathematics	79.3% 38.3%
Experience (See Chapter 4 Table 19)	Less than 15 years	52.9%

This study confirmed that Grade 9 learners in South Africa achieved the highest mean mathematics mark in classes taught by teachers with only a matric certificate and the lowest mark in classes taught by teachers that have a post-matric certificate (Chapter 4, Figure 9). Factors such as the age of the teachers (Chapter 4, Figure 10) and even class size (Chapter 4, Figure 11) were investigated to shed light on these remarkable phenomena and in neither of the instances, could the factors provide a possible explanation. Since the sample of the learners taught by teachers that have only achieved either a matric or post-matric certificate was so small, the reliability of this finding cannot be confirmed.

When only considering the mean mathematics mark of learners taught by teachers with an education level that varies from a diploma up to an honours and higher degree, it is evident that the difference in the mean mathematics marks between a diploma and an honours degree is 21.34 (Chapter 4, Table 21). As such, it can be deducted that the educational level of teachers did influence the mathematics performance of the learners positively. The teacher with a higher educational level will possibly elicit better mathematics performance.

The analysis of the influence of mathematics and education mathematics as major areas of study, conveyed that teachers with education mathematics as major area of study had a positive influence on their learners' performance (Chapter 4, Figure 13) in contrast to the influence of teachers with mathematics as major area of study (Chapter 4, Figure 12). Further analysis was done by also considering the level of education combined with the major areas of study (Chapter 4, Tables 22 and 23).

The influence of teaching experience on the mathematics performance was explored by using three teacher development stages models as proposed by Katz (1972), Huberman (in Joerger, 2010) and Day (2012). The mathematics performance of learners was thereafter further investigated according to years of teaching experience.

Teachers in the Katz' (1972) "Survival" stage (year 1 of their teaching careers) had the best influence on learner performance. The mean mathematics performance of learners taught by teachers in this stage was 366.2, whereas learners whose teachers have reached maturity (years 5+) only achieved 354.11. None of the differences in the mean performance values according to Katz' model was significant (see Chapter 4, Table 30).

Huberman's model (in Joerger, 2010), used as basis for the data analysis, conveyed two stages, Experimentation/Diversification (years 7-18) and Disengagement (years 31-43) as optimum for learner performance. The mean performance marks of learners whose teachers were in the first three stages increased as expected. The low mean performance of 341.83 (see Chapter 4, Table 31) in the stage Conservatism/Serenity (19 to 30 years), calls for further exploration.

The mean mathematics performance mark of learners whose teachers are in the first three development stages, as proposed by Day (2012), increased from 343.03 to 366.57 (see Chapter 4, Table 33). Day's (2012) division of the years 16 to 30 into stages where work-life tensions and challenges to sustain motivation are experienced, reflected in the mean performance marks in the years 16-23 (348.44) and then 24-30 (335.70).

The graph in Figure 17 (Chapter 4) displayed the mean performance marks of learners across every year of teacher experience. The highest mean mathematics mark (454) was achieved in a class with a teacher that has 43 years of experience.

3 Discussion

Initially, the research started off as an investigation into the influence of the teacher and his or her teaching approaches on the mathematics performance of learners. Since data on the mathematics performance of Grade 9 learners was available and the data set also included background questionnaires, and not only the results on the mathematics performance tests, TIMSS 2011 was chosen as basis for the research. As a result, a quantitative approach was followed. However, after carefully evaluating the questions on the questionnaires and the corresponding responses, the reliability of the research in the absence of the option to triangulate the results by performing interviews, obliged the researcher to rather look into the influence of teacher credentials on the mathematics performance of learners.

The influence of teacher credentials on the mathematics performance of the learners was investigated using a quantitative approach. The TIMSS data set was suitable to answer the research questions since the questions in the teacher background questionnaire addressed the relevant teacher credentials. Furthermore, the influence of teacher credentials on learner performance could be investigated since the learner performance results could be linked to the relevant teachers. It would have been useful, however, to interview the teachers with regard to their responses to the questions in the teacher background questionnaire in connection with their qualifications and especially their major area of study (being mathematics or education mathematics). As a result of teacher education reform in South Africa, the teachers' responses might not be accurate enough to make valid deductions in South African context.

The influence of teachers' academic degrees on the performance of learners was the topic of numerous studies (Hanushek & Rivkin ,2006; Rice, 2003; Rosenthal, 2007). The rulings were inconclusive. It seems, in the South African context, as if the mean mathematics mark of learners is positively influenced by the educational level (as indicated in the responses) of the teachers. However, the context of teacher education in South Africa should be taken into account before any deductions can be made. The standard of training at teacher colleges differed because of the fact that the administration of the institutions did not fall under one governing entity. Furthermore, after 1994, considerable changes in teacher education led to substantial differences in the qualifications of teachers, especially with regard to the major areas of study. As discussed in Chapter 4, teachers do not seem to know whether they had mathematics or education mathematics as major area of study. The age of the teacher may give an indication of the era in which the teacher has graduated but this may also not be accurate since no information regarding the starting date of study is available. Even teachers whose highest level of education is matric, indicate that they have mathematics and education mathematics as major area of study. This fact cautions the formulating of any theory regarding the influence of mathematics and education mathematics as major areas of study on the mathematics performance of the learners. More information regarding the institution in South Africa where the teacher has graduated and the year of graduation are needed before any attempt to validate the findings can be made.

Notwithstanding these qualifications, the major areas of study produced interesting results. The majority of the learners' teachers (8 258 of 10 435 learners) indicated that they had mathematics as major area of study. Unexpectedly, learners in classes with teachers that had mathematics as major area of study, had lower mean mathematics marks than their counterparts. However, learners (about 40% of the learners) whose teachers had education mathematics as major area of study outperformed their counterparts. Once the education level and the major area of study were combined, the regression coefficient indicated that learners whose teachers have a diploma without mathematics as major area of study, achieved on average 53 marks less than the mean performance of the group (a significant difference according to the results of the t-test). When we consider the mean performance of learners whose teachers had a diploma with education mathematics as major area of study, learners achieved 30.53 marks less than the grand mean for the other learners. Even though the applied and hands-on approach followed by teacher training colleges is widely appraised (Chisholm, 2009), learners in a class with a teacher that obtained a first degree, outperformed their counterparts where the teacher had only completed a diploma.

Teaching experience is another teacher credential frequently discussed in literature (Day, 2012; Dreyfus, 2004; Joerger, 2010; Katz, 1972). Since learning occurs in a broader framework concerning a teacher's personal and professional development, teaching experience may influence the performance of learners either positively or negatively (Day, 1999).

There is no significant difference between the grand mean of the learners' mathematics mark and any of the teacher development stages as proposed by Katz (1972). Surprisingly, learners in classes with teachers who have only one year of teaching experience outperformed the whole spectra of learners. This seems to be contradictory to the general impression of a novice teacher wrapped up in Katz' teacher question: Will I survive this day? The difference in the average mathematics mark between year one and two, confirm the statement regarding the decline of teachers' self-efficacy (in the period between teacher training, at the end of their practicum experiences and the end of their first year of teaching) as a result of "a reality shock at the end of Year 1 of experience in the classroom" (Klassen, 2014, p. 103).

Katz' developmental model does not allow investigation after five years of teaching experience and, for this reason, Huberman's developmental stages for teachers were also investigated. The mean mathematics mark was 9.6 marks above the grand mean for 7 to 18 years teaching experience (at a 20% level of significance) and 10.9 marks below the grand mean for 19 to 30 years teaching experience, also on a 20% level of significance. The 20 marks difference between the stages 19 to 30 years, and 31 to 43 years of experience, focused attention on these years and yet another development stages model was employed. Day divided these stages (from 19 to 30 years as proposed by Huberman) in the following year categories: 16-23 and 24-30. The mean mathematics performance mark of learners, whose teachers have between eight and 15 years of experience, is 14.6 marks above the grand mean performance score of all of the learners (at a 10% level of significance). When considering teachers with between 24 and 30 years of experience, the learners have 16 marks below the grand mean of the mathematics performance of all of the learners (also at a 10% level of significance). Even though teachers' self-efficacy, according to Klassen (2014) reaches a maximum at 23 years of experience, the results illustrated that teachers who have between 24 and 30 years of experience need support, not necessarily in the execution of their teaching jobs, but to help them to deal with their personal environment in order to improve their learners' marks.

Apart from investigating the influence of teaching experience on the performance of learners by using different development stages models, the years of teaching experience were also plotted in comparison to learner performance. It seems as if in the South African context there are two strands of mean performance marks in the first twelve years of teaching experience: 329 to 368 and also 366 to 406. The overall performance of learners, whose teachers have between 13 and 26 years of experience, differs between 322 and 377 and after 27 years of experience, the variation in the mean performance marks between consecutive years, is large.

Although the study did not deal with the specifics since it was based on the TIMSS assessment in 2011, it is conducted within the context of South Africa. Socioeconomic challenges, training of teachers and language are only a few of the factors faced in the education of the learners. Teacher qualifications seemed to have an influence on the mathematics performance of learners, but it should be interpreted within South African context. Furthermore, when considering teacher experience, it appears as if the developmental stages of teachers, as proposed by Day, could give an indication of the influence that a teacher with a certain number of years' experience could have on the mathematics performance of learners.

4 Recommendations

To be able to provide insight in the South African context on the influence of teacher credentials on learner performance, the questions posed, to establish the educational level of a teacher, should take the history of teacher education in South Africa into account. As such, the response options to the questions could be elaborated or the questions could be constructed in such a way that the teachers would not be perplexed about their educational level or major areas of study.

Teacher professional development courses should take the teacher development stages into account. The fact that teachers have experience does not imply that they will be able to manage all of the different facets related to a teaching career. Developmental courses could focus on teachers with more than 15 years of experience, especially around motivation and crises management because it seems as if the performance of learners, whose teachers are in these development stages, could be improved by assisting the teacher in these stages of their lives.

It would be interesting to know how the teachers, that took part in TIMSS assessments prior to the 2011 assessment, especially assessments around the year 2000, have answered the questions regarding educational level and also the whether the influence of teacher credentials will be similar across different years and also across countries. Using a mixed method approach the results could possibly be strengthened

Another suggestion for further research is to investigate whether the educational reform in South Africa had a positive influence on the mathematics performance of learners by using all of the TIMSS assessment data available.

5 Closure

The teacher, as the person who is supposed to make hard things easy (Emersonquotes Tillotson, 2016), is one of the biggest determinants of learner performance. As such, the teaching profession should once again be reckoned and respected as one the crucial components for progress in a country and especially in South Africa.

"One child, one teacher, one book, one pen can change the world."
— Malala Yousafzai

(Roterman, 2016)

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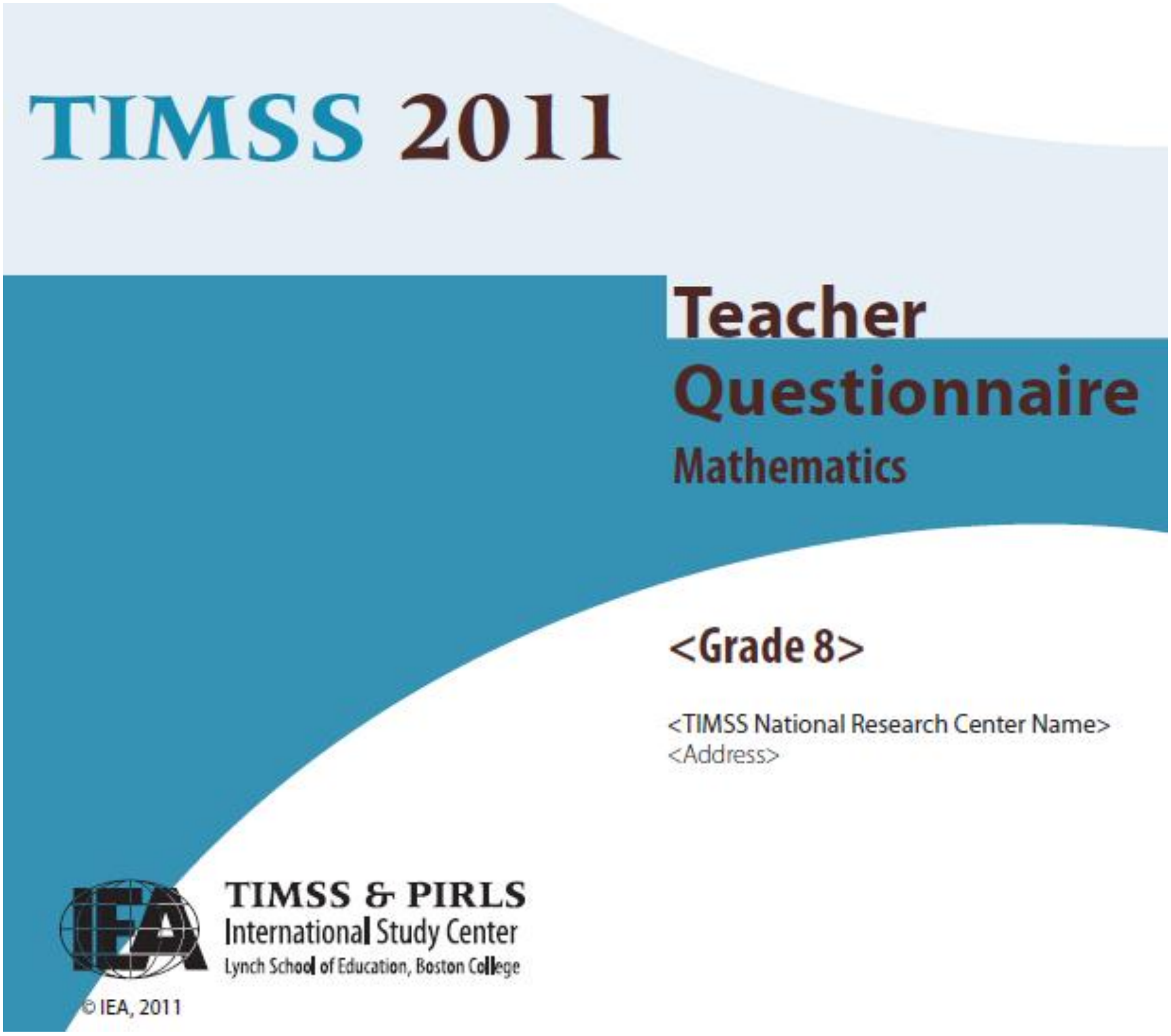
Addenda

1 Addendum A



About You

1

By the end of this school year, how many years will you have been teaching altogether?

_______________ years
*Please **round** to the nearest whole number.*

2

Are you female or male?

*Check **one** circle only.*

- Female --- ○
- Male --- ○

3

How old are you?

*Check **one** circle only.*

- Under 25 --- ○
- 25–29 --- ○
- 30–39 --- ○
- 40–49 --- ○
- 50–59 --- ○
- 60 or more --- ○

4

What is the highest level of formal education you have completed?

*Check **one** circle only.*

- Did not complete <ISCED Level 3> --- ○
- Finished <ISCED Level 3> --- ○
- Finished <ISCED Level 4> --- ○
- Finished <ISCED Level 5B> --- ○
- Finished <ISCED Level 5A, first degree> --- ○
- Finished <ISCED Level 5A, second degree> or higher --- ○

5

During your <post-secondary> education, what was your major or main area(s) of study?

*Check **one** circle for each line.*

	Yes	No
a) Mathematics	○	○
b) Biology	○	○
c) Physics	○	○
d) Chemistry	○	○
e) <Earth Science>	○	○
f) Education–Mathematics	○	○
g) Education–Science	○	○
h) Education–General	○	○
i) Other	○	○

2 Addendum B Data Analysis

The data analysis, Addendum B, is burnt on a CD-ROM obtainable at the back of the dissertation

Analysis of Data

Addenda

1 Teacher profile

1.1 Gender distribution

In terms of number of teachers

GEN\SEX OF TEACHER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	FEMALE	138	42.2	46.3	46.3
	MALE	160	48.9	53.7	100.0
	Total	298	91.1	100.0	
Missing	System	29	8.9		
Total		327	100.0		

In terms of number of learners

GEN\SEX OF TEACHER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	FEMALE	4921	41.1	44.3	44.3
	MALE	6191	51.7	55.7	100.0
	Total	11112	92.8	100.0	
Missing	System	857	7.2		
Total		11969	100.0		

Summary of data: gender

	Number of male and female teachers	Percent	Number of learners taught by male and female teachers	Percent
Female	138	46.3	4 921	44.3
Male	160	53.7	6 191	55.7
Total	**298**	**100.0**	**11 112**	**100.0**
Chi-square p-value	**0.203**		**0.000*** **	

1.2 Age group

In terms of number of teachers

GEN\AGE OF TEACHER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	UNDER 25	9	2.8	3.0	3.0
	25-29	44	13.5	14.9	17.9
	30-39	87	26.6	29.4	47.3
	40-49	103	31.5	34.8	82.1
	50-59	47	14.4	15.9	98.0
	60 OR MORE	6	1.8	2.0	100.0
	Total	296	90.5	100.0	
Missing	OMITTED OR INVALID	2	.6		
	System	29	8.9		
	Total	31	9.5		
Total		327	100.0		

In terms of number of learners

GEN\AGE OF TEACHER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	UNDER 25	294	2.5	2.7	2.7
	25-29	1563	13.1	14.2	16.9
	30-39	3277	27.4	29.8	46.7
	40-49	3956	33.1	36.0	82.7
	50-59	1707	14.3	15.5	98.2
	60 OR MORE	198	1.7	1.8	100.0
	Total	10995	91.9	100.0	
Missing	OMITTED OR INVALID	117	1.0		
	System	857	7.2		
	Total	974	8.1		
Total		11969	100.0		

Summary of data: age of teachers

	Number of teachers in each age category	**Percent**	**Number of learners taught by teachers in each age category**	**Percent**
Under 25	9	3.0	294	2.7
25-29	44	14.9	1 563	14.2
30-39	87	29.4	3 277	29.8
40-49	103	34.8	3 956	36.0
50-59	47	15.9	1 707	15.5
60 or more	6	2.0	198	1.8
Total	**296**	**100.0**	**10 995**	**100.0**
Chi-square p-value	**0.000*** **		**0.000*** **	

1.3 Highest level of education

In terms of number of teachers

GEN\LEVEL OF FORMAL EDUCATION COMPLETED

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	<ISCED LEVEL 3>	4	1.2	1.4	1.4
	<ISCED LEVEL 4>	2	.6	.7	2.1
	<ISCED LEVEL 5B>	106	32.4	37.2	39.3
	<ISCED LEVEL 5A, 1ST>	119	36.4	41.8	81.1
	<ISCED LEVEL 5A, 2ND>	54	16.5	18.9	100.0
	Total	285	87.2	100.0	
Missing	OMITTED OR INVALID	13	4.0		
	System	29	8.9		
	Total	42	12.8		
Total		327	100.0		

In terms of number of learners

GEN\LEVEL OF FORMAL EDUCATION COMPLETED

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<ISCED LEVEL 3>	201	1.7	1.9	1.9
	<ISCED LEVEL 4>	98	.8	.9	2.8
	<ISCED LEVEL 5B>	4045	33.8	38.4	41.2
	<ISCED LEVEL 5A, 1ST>	4317	36.1	40.9	82.1
	<ISCED LEVEL 5A, 2ND>	1882	15.7	17.9	100.0
	Total	10543	88.1	100.0	
Missing	OMITTED OR INVALID	569	4.8		
	System	857	7.2		
	Total	1426	11.9		
Total		11969	100.0		

The translation of the variables for the South African context:

Variables in South African context

International	South Africa
<ISCED LEVEL 3>	Passed Grade 12
<ISCED LEVEL 4>	Obtained a post-matric certificate
<ISCED LEVEL 5B>	Obtained a diploma
<ISCED LEVEL 5A, 1ST>	Obtained a first degree
<ISCED LEVEL 5A, 2ND>	Obtained an honours degree+

Summary of data: Level of formal education completed

	Number of teachers that completed each level	Percent	Number of learners taught by teachers that completed each level	Percent
Passed Grade 12	4	1.4	201	1.9
Obtained a post-matric certificate	2	0.7	98	0.9
Obtained a diploma	106	37.2	4 045	38.4
Obtained a first degree	119	41.8	4 317	40.9
Obtained an honours degree+	54	18.9	1 882	17.9
Total	**285**	**100.0**	**10 543**	**100.0**
Chi-square p-value	**0.000*** **		**0.000*** **	

1.4 Mathematics as major area of study

In terms of number of teachers

GEN\MAJOR AREA OF STUDY\MATHEMATICS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	233	71.3	79.3	79.3
	NO	61	18.7	20.7	100.0
	Total	294	89.9	100.0	
Missing	OMITTED OR INVALID	4	1.2		
	System	29	8.9		
	Total	33	10.1		
Total		327	100.0		

In terms of number of learners

GEN\MAJOR AREA OF STUDY\MATHEMATICS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	8783	73.4	80.1	80.1
	NO	2177	18.2	19.9	100.0
	Total	10960	91.6	100.0	
Missing	OMITTED OR INVALID	152	1.3		
	System	857	7.2		
	Total	1009	8.4		
Total		11969	100.0		

Summary of data: Major area of study-mathematics

	Number of teachers with mathematics as major area of study	Percent	Number of learners taught by teachers with mathematics as major area of study	Percent
Yes	233	79.3	8 783	80.1
No	61	20.7	2 177	19.9
Total	**294**	**100.0**	**10 960**	**100.0**
Chi-square p-value	**0.000*** **		**0.000*** **	

1.5 Education-Mathematics as major area of study

In terms of number of teachers

GEN\MAJOR AREA OF STUDY\EDU MATHEMATICS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	111	33.9	38.3	38.3
	NO	179	54.7	61.7	100.0
	Total	290	88.7	100.0	
Missing	OMITTED OR INVALID	8	2.4		
	System	29	8.9		
	Total	37	11.3		
Total		327	100.0		

In terms of number of learners

GEN\MAJOR AREA OF STUDY\EDU MATHEMATICS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	4195	35.0	38.8	38.8
	NO	6617	55.3	61.2	100.0
	Total	10812	90.3	100.0	
Missing	OMITTED OR INVALID	300	2.5		
	System	857	7.2		
	Total	1157	9.7		
Total		11969	100.0		

Summary of data: Major area of study-education mathematics

	Number of teachers with education-mathematics as major area of study	Percent	Number of learners taught by teachers with education-mathematics as major area of study	Percent
Yes	111	38.3	4 195	38.8
No	179	61.7	6 617	61.2
Total	**290**	**100.0**	**10 812**	**100.0**
Chi-square p-value	**0.000***		**0.000***	

1.6 Professional development courses attended

In terms of number of learners

MATH\PROF DEVELOPMENT\MATH CONTENT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	8089	67.6	74.6	74.6
	NO	2756	23.0	25.4	100.0
	Total	10845	90.6	100.0	
Missing	OMITTED OR INVALID	267	2.2		
	System	857	7.2		
	Total	1124	9.4		
Total		11969	100.0		

MATH\PROF DEVELOPMENT\MATH PEDAGOGY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	5512	46.1	50.9	50.9
	NO	5323	44.5	49.1	100.0
	Total	10835	90.5	100.0	
Missing	OMITTED OR INVALID	277	2.3		
	System	857	7.2		
	Total	1134	9.5		
Total		11969	100.0		

MATH\PROF DEVELOPMENT\MATH CURRICULUM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	8095	67.6	74.2	74.2
	NO	2810	23.5	25.8	100.0
	Total	10905	91.1	100.0	
Missing	OMITTED OR INVALID	207	1.7		
	System	857	7.2		
	Total	1064	8.9		
Total		11969	100.0		

MATH\PROF DEVELOPMENT\IT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	3506	29.3	32.1	32.1
	NO	7432	62.1	67.9	100.0
	Total	10938	91.4	100.0	
Missing	OMITTED OR INVALID	174	1.5		
	System	857	7.2		
	Total	1031	8.6		
Total		11969	100.0		

MATH\PROF DEVELOPMENT\CRITICAL THINKING

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	5424	45.3	49.4	49.4
	NO	5553	46.4	50.6	100.0
	Total	10977	91.7	100.0	
Missing	OMITTED OR INVALID	135	1.1		
	System	857	7.2		
	Total	992	8.3		
Total		11969	100.0		

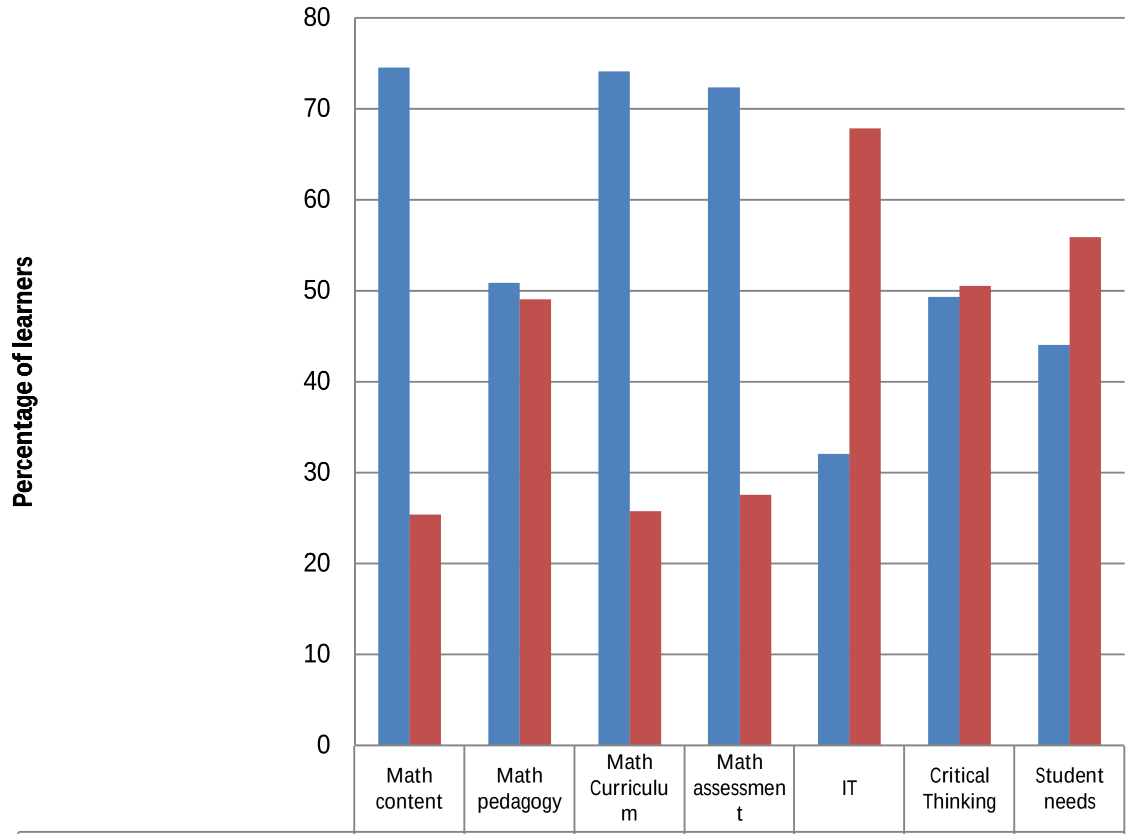
MATH\PROF DEVELOPMENT\MATH ASSESSMENT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	7885	65.9	72.4	72.4
	NO	2999	25.1	27.6	100.0
	Total	10884	90.9	100.0	
Missing	OMITTED OR INVALID	228	1.9		
	System	857	7.2		
	Total	1085	9.1		
Total		11969	100.0		

MATH\PROF DEVELOPMENT\STUDENT NEEDS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	4806	40.2	44.1	44.1
	NO	6081	50.8	55.9	100.0
	Total	10887	91.0	100.0	
Missing	OMITTED OR INVALID	225	1.9		
	System	857	7.2		
	Total	1082	9.0		
Total		11969	100.0		

Summary of data: Professional development courses attended (percentage of learners)



	Math content	Math pedagogy	Math Curriculum	Math assessment	IT	Critical Thinking	Student needs
teachers attended the course	74.6	50.9	74.2	72.4	32.1	49.4	44.1
teachers did not attend the course	25.4	49.1	25.8	27.6	67.9	50.6	55.9

1.7 Years of teaching experience

In terms of number of teachers

GEN\YEARS BEEN TEACHING

		Frequency	Percent	Valid Percent	Cumulative Percent
	1	7	2.1	2.4	2.4
	2	13	4.0	4.5	6.9
	3	20	6.1	6.9	13.7
Valid	4	16	4.9	5.5	19.2
	5	12	3.7	4.1	23.4
	6	11	3.4	3.8	27.1
	7	9	2.8	3.1	30.2

GEN\YEARS BEEN TEACHING

		Frequency	Percent	Valid Percent	Cumulative Percent
	8	9	2.8	3.1	33.3
	9	16	4.9	5.5	38.8
	10	11	3.4	3.8	42.6
	11	10	3.1	3.4	46.0
	12	3	.9	1.0	47.1
	13	6	1.8	2.1	49.1
	14	11	3.4	3.8	52.9
	15	12	3.7	4.1	57.0
	16	9	2.8	3.1	60.1
	17	11	3.4	3.8	63.9
	18	11	3.4	3.8	67.7
	19	13	4.0	4.5	72.2
	20	15	4.6	5.2	77.3
	21	10	3.1	3.4	80.8
	22	4	1.2	1.4	82.1
	23	8	2.4	2.7	84.9
	24	9	2.8	3.1	88.0
	25	7	2.1	2.4	90.4
	26	3	.9	1.0	91.4
	27	3	.9	1.0	92.4
	28	5	1.5	1.7	94.2
	30	6	1.8	2.1	96.2
	31	1	.3	.3	96.6
	32	1	.3	.3	96.9
	33	1	.3	.3	97.3
	34	1	.3	.3	97.6
	35	2	.6	.7	98.3
	36	2	.6	.7	99.0
	39	1	.3	.3	99.3
	42	1	.3	.3	99.7
	43	1	.3	.3	100.0
	Total	291	89.0	100.0	
	OMITTED OR INVALID	7	2.1		
Missing	System	29	8.9		
	Total	36	11.0		
Total		327	100.0		

In terms of number of learners

GEN\YEARS BEEN TEACHING

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	319	2.7	2.9	2.9
	2	466	3.9	4.3	7.2
	3	673	5.6	6.2	13.4
	4	591	4.9	5.4	18.8
	5	478	4.0	4.4	23.2
	6	446	3.7	4.1	27.3
	7	305	2.5	2.8	30.1
	8	354	3.0	3.3	33.4
	9	569	4.8	5.2	38.6
	10	379	3.2	3.5	42.1
	11	385	3.2	3.5	45.6
	12	127	1.1	1.2	46.8
	13	169	1.4	1.6	48.3
	14	423	3.5	3.9	52.2
	15	380	3.2	3.5	55.7
	16	365	3.0	3.4	59.0
	17	448	3.7	4.1	63.2
	18	493	4.1	4.5	67.7
	19	481	4.0	4.4	72.1
	20	609	5.1	5.6	77.7
	21	343	2.9	3.2	80.9
	22	123	1.0	1.1	82.0
	23	270	2.3	2.5	84.5
	24	344	2.9	3.2	87.6
	25	276	2.3	2.5	90.2
	26	115	1.0	1.1	91.2
	27	89	.7	.8	92.0
	28	176	1.5	1.6	93.6
	30	256	2.1	2.4	96.0
	31	29	.2	.3	96.3
	32	40	.3	.4	96.6
	33	43	.4	.4	97.0
	34	54	.5	.5	97.5
	35	90	.8	.8	98.3
	36	83	.7	.8	99.1
	39	27	.2	.2	99.4
	42	34	.3	.3	99.7
	43	36	.3	.3	100.0
	Total	10888	91.0	100.0	
Missing	OMITTED OR INVALID	224	1.9		

GEN\YEARS BEEN TEACHING

		Frequency	Percent	Valid Percent	Cumulative Percent
	System	857	7.2		
	Total	1081	9.0		
Total		11969	100.0		

Summary of data: Years of experience

	Number of teachers in each category	Percent	Number of learners taught by teachers in each category	Percent
<10	113	38.8	4 201	38.6
10-14	41	14.1	1 483	13.6
15-19	56	19.2	2 167	19.9
20-24	46	15.8	1 689	15.5
25-29	18	6.2	656	6
30-34	10	3.4	422	3.9
35-39	5	1.7	200	1.8
40-44	2	0.7	70	0.6
Total	**291**	**100.0**	**10 995**	**100.0**
Chi-square p-value	**0.000***		**0.000***	

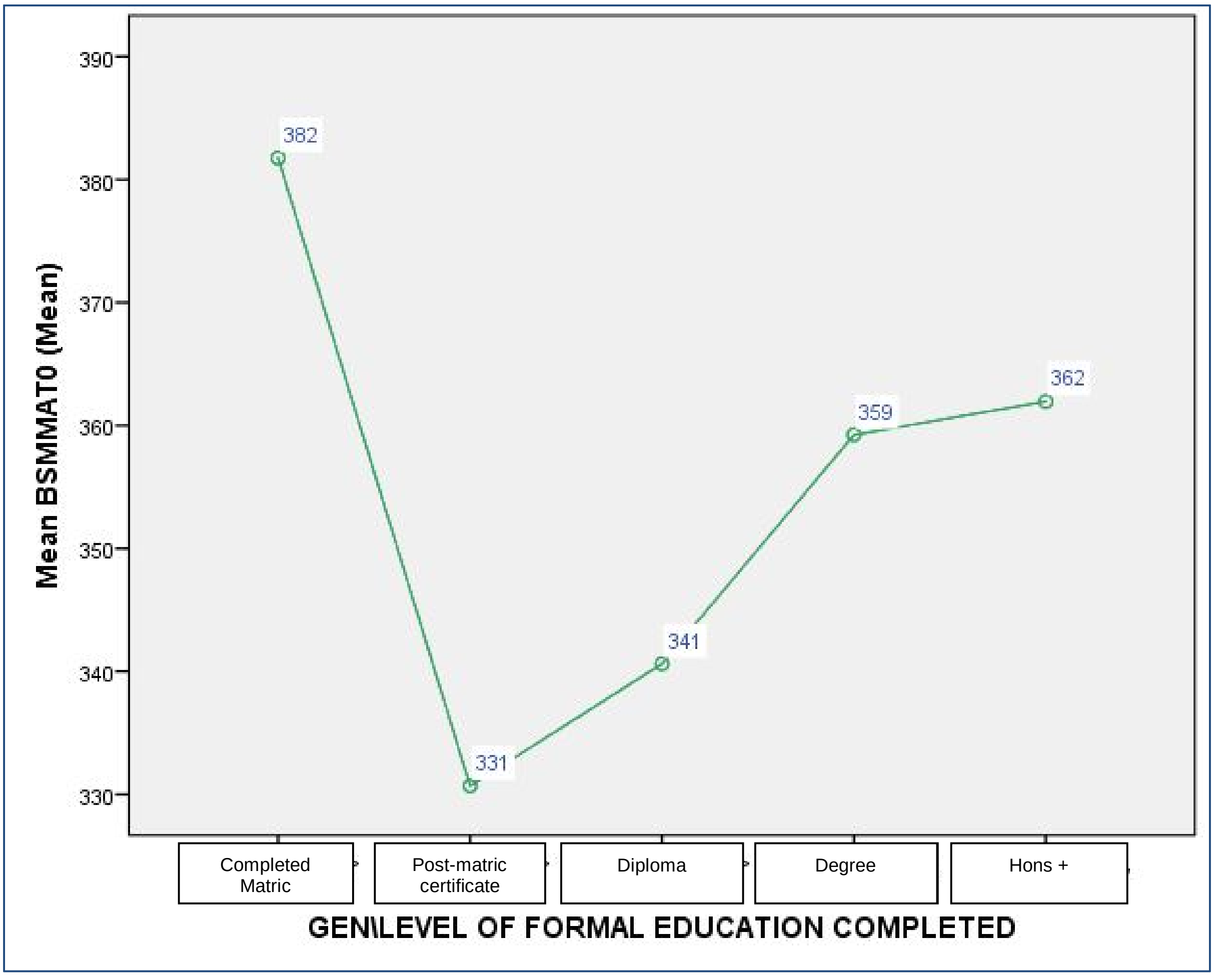
2 Teacher qualifications vs Learner performance

BTBG04	n	pct	pct_se	mnpv	mnpv_se	sdpv	sdpv_se
<ISCED LEVEL 3>	201	1.66	0.99	381.76	35.07	78.70	13.72
<ISCED LEVEL 4>	98	0.39	0.32	330.69	8.52	59.75	7.45
<ISCED LEVEL 5B>	4 045	38.10	3.86	340.62	6.04	79.71	4.63
<ISCED LEVEL 5A, 1ST>	4 317	42.22	3.43	359.24	5.75	91.95	3.07
<ISCED LEVEL 5A, 2ND>	1 882	17.63	2.95	361.95	9.09	89.62	5.67

Summary of data: Number of learners, mean and standard error of pv's taught by teachers in each category of level of formal education

Gen\level of formal education completed		**Mean of plausible values**	**Standard error of plausible values**
	N	**mnpv**	**sdpv**
Finished Grade 12	201	381.76	78.70
Finished post-matric certificate	98	330.69	59.75
Finished diploma	4 045	340.62	79.71
Finished first degree	4 317	359.24	91.95
Finished honours degree or higher	1 882	361.95	89.62
Total	10 543		

Graphical representation of data: Level of formal education vs mean of the Mathematics performance mark based on pv's



Linear regression coefficient with effect coding where E1 was the reference category.

EqVar	b	b.se	b.t
(CONSTANT)	354.8501	7.4147	47.8574
BTBG04_E2	-24.1610	9.8583	-2.4508
BTBG04_E3	-14.2350	9.7409	-1.4614
BTBG04_E4	4.3878	8.7311	0.5025
BTBG04_E5	7.0972	10.5616	0.6720

Linear regression coefficient with effect coding where E2 was the reference category.

EqVar	b	beta	b.se	beta.se	b.t	beta.t
(CONSTANT)	354.8501	#NULL!	7.4147	#NULL!	47.8574	#NULL!
BTBG04_E1	26.9111	0.0439	28.2882	0.0387	0.9513	1.1332
BTBG04_E3	-14.2350	-0.0803	9.7409	0.0552	-1.4614	-1.4545
BTBG04_E4	4.3878	0.0251	8.7311	0.0500	0.5025	0.5024
BTBG04_E5	7.0972	0.0315	10.5616	0.0463	0.6720	0.6805

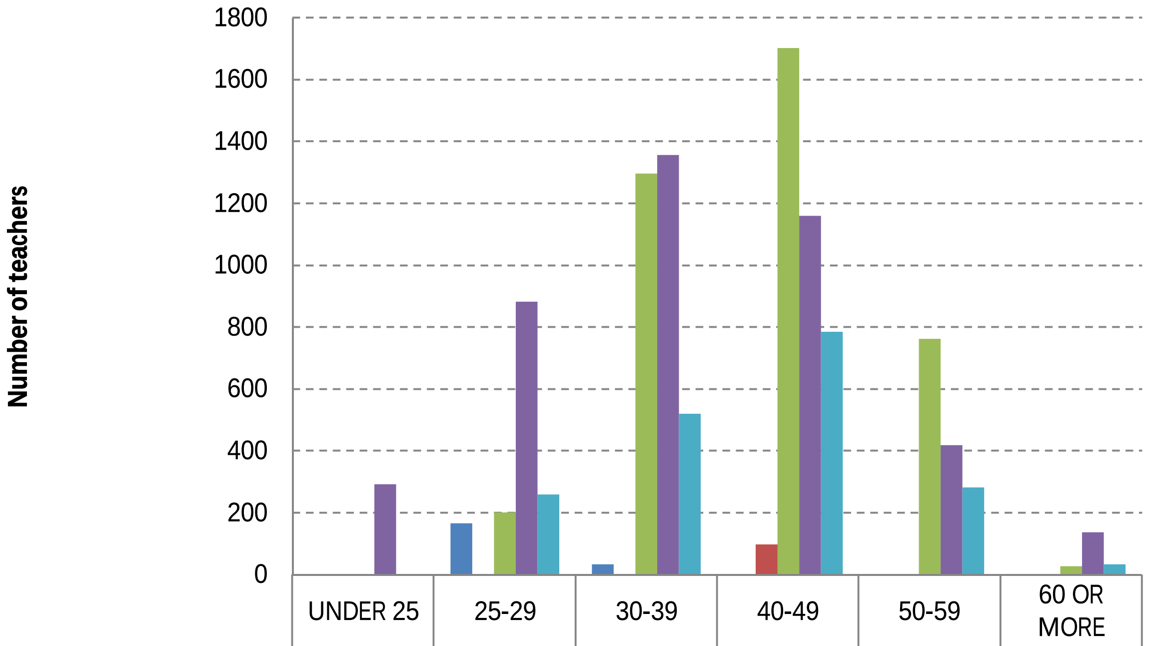
Summary of data: Significance in performance of learners taught by teachers with different levels of formal education

		Regression coefficient	**Regression coefficient (standard error)**	**Regression coefficient (t-value)**
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		354.85	7.41	47.86
BTBG04_E1	Matric	26.91	28.29	0.95
BTBG04_E2	Post-matric certificate	-24.16	9.86	-2.45***
BTBG04_E3	Diploma	-14.24	9.74	-1.46*
BTBG04_E4	First degree	4.39	8.73	0.50
BTBG04_E5	Hons+	7.10	10.56	0.67

2.1 Qualification vs teacher's age

		GEN\AGE OF TEACHER					
		UNDER 25	25-29	30-39	40-49	50-59	60 OR MORE
		Count	Count	Count	Count	Count	Count
GEN\LEVEL OF FORMAL EDUCATION COMPLETED	NOT COMPL <ISCED 3>	0	0	0	0	0	0
	<ISCED LEVEL 3>	0	166	35	0	0	0
	<ISCED LEVEL 4>	0	0	0	98	0	0
	<ISCED LEVEL 5B>	0	202	1297	1703	764	27
	<ISCED LEVEL 5A, 1ST>	294	884	1357	1160	420	137
	<ISCED LEVEL 5A, 2ND>	0	260	520	785	283	34

Graphical representation of data: Age vs Teacher qualification



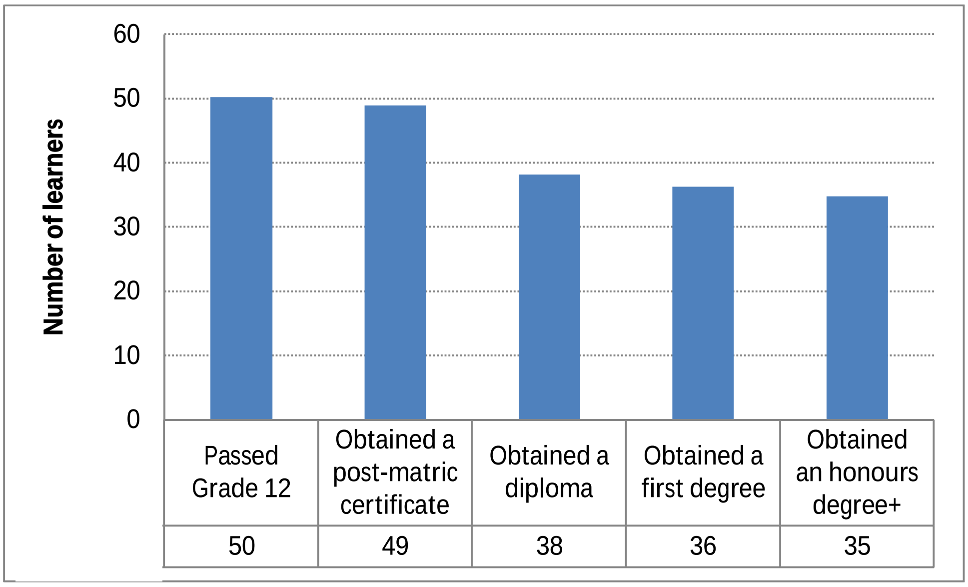
	UNDER 25	25-29	30-39	40-49	50-59	60 OR MORE
Matric	0	166	35	0	0	0
Post-Matric certificate	0	0	0	98	0	0
Diploma	0	202	1297	1703	764	27
First Degree	294	884	1357	1160	420	137
Hons+	0	260	520	785	283	34

2.2 Class size

Results were obtained from previous tables. Class size calculation done in last column.

.	**Number of teachers that completed each level**	**Percent**	**Number of learners taught by teachers that completed each level**	**Percent**	**Number of learners/number of teachers**
Passed Grade 12	4	1.4	201	1.9	50
Obtained a post-matric certificate	2	0.7	98	0.9	49
Obtained a diploma	106	37.2	4 045	38.4	38
Obtained a first degree	119	41.8	4 317	40.9	36
Obtained an honours degree+	54	18.9	1 882	17.9	35
Total	**285**	**100**	**10 543**	**100**	

Graphical representation of data: Class sizes vs Teacher qualification

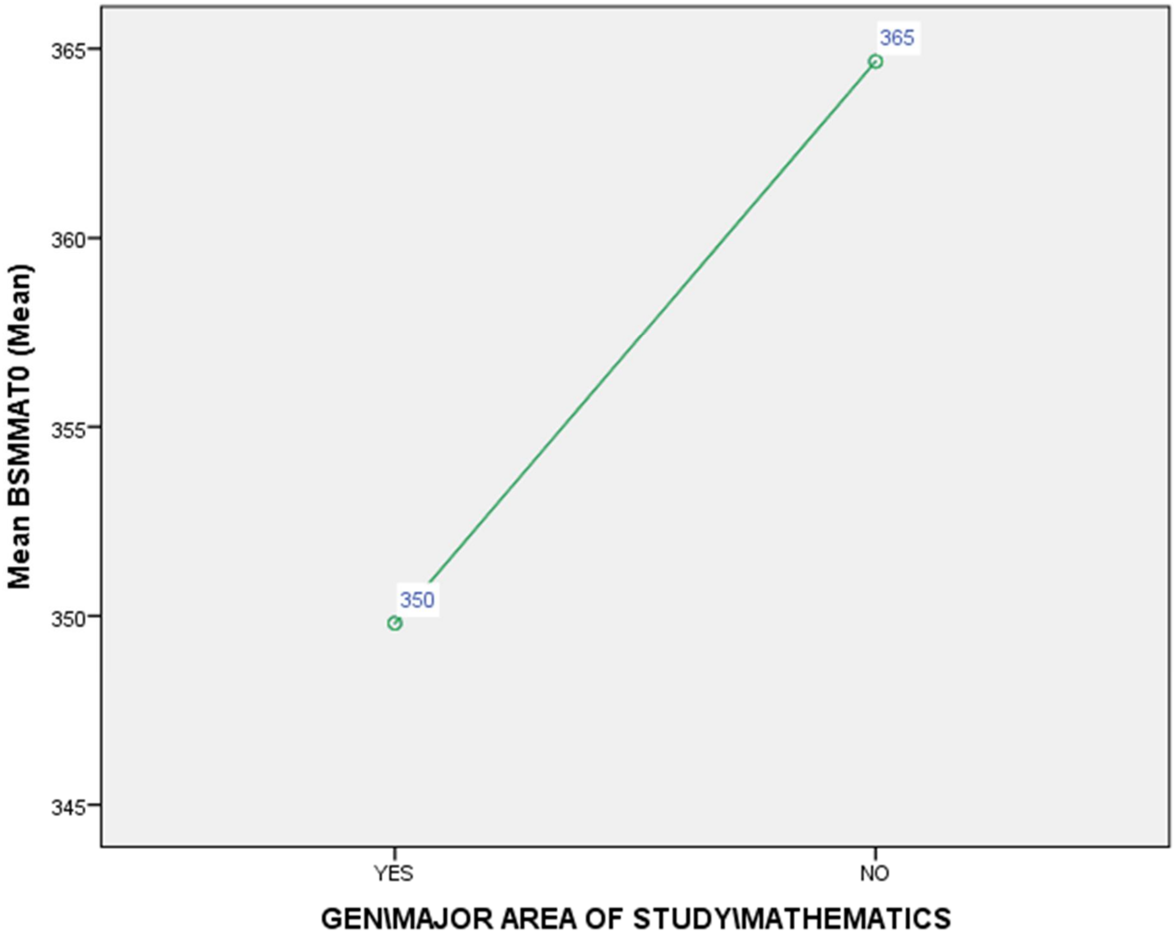


2.3 Analysis of major areas of study vs learner performance

2.3.1 Mathematics as major

BTBG05A	dvar	n	pct	pct_se	mnpv	mnpv_se	sdpv	sdpv_se
YES	BSMMAT0	8 783	81.66	2.99	349.81	3.60	86.13	2.71
NO	BSMMAT0	2 177	18.34	2.99	364.66	10.85	88.70	4.40

Graphical representation of data: Mathematics as major vs average mathematics performance



Linear regression coefficient with dummy coding where D1 was the reference category.

Regression Coefficients

IDCNTRY	Variable	Regression Coefficient	Regression Coefficient (s.e.)	Regression Coefficient (t-value)	Stndrdzd. Coefficient	Stndrdzd. Coefficient (s.e.)	Stndrdzd. Coefficient (t-value)
South Africa	(CONSTANT)	364.66	10.85	33.62	.	.	.
	BTBG05A_D1	-14.86	12.61	-1.18	-.07	.06	-1.20
Table Average	(CONSTANT)	364.66	10.85	33.62	.	.	.
	BTBG05A_D1	-14.86	12.61	-1.18	-.07	.06	-1.20

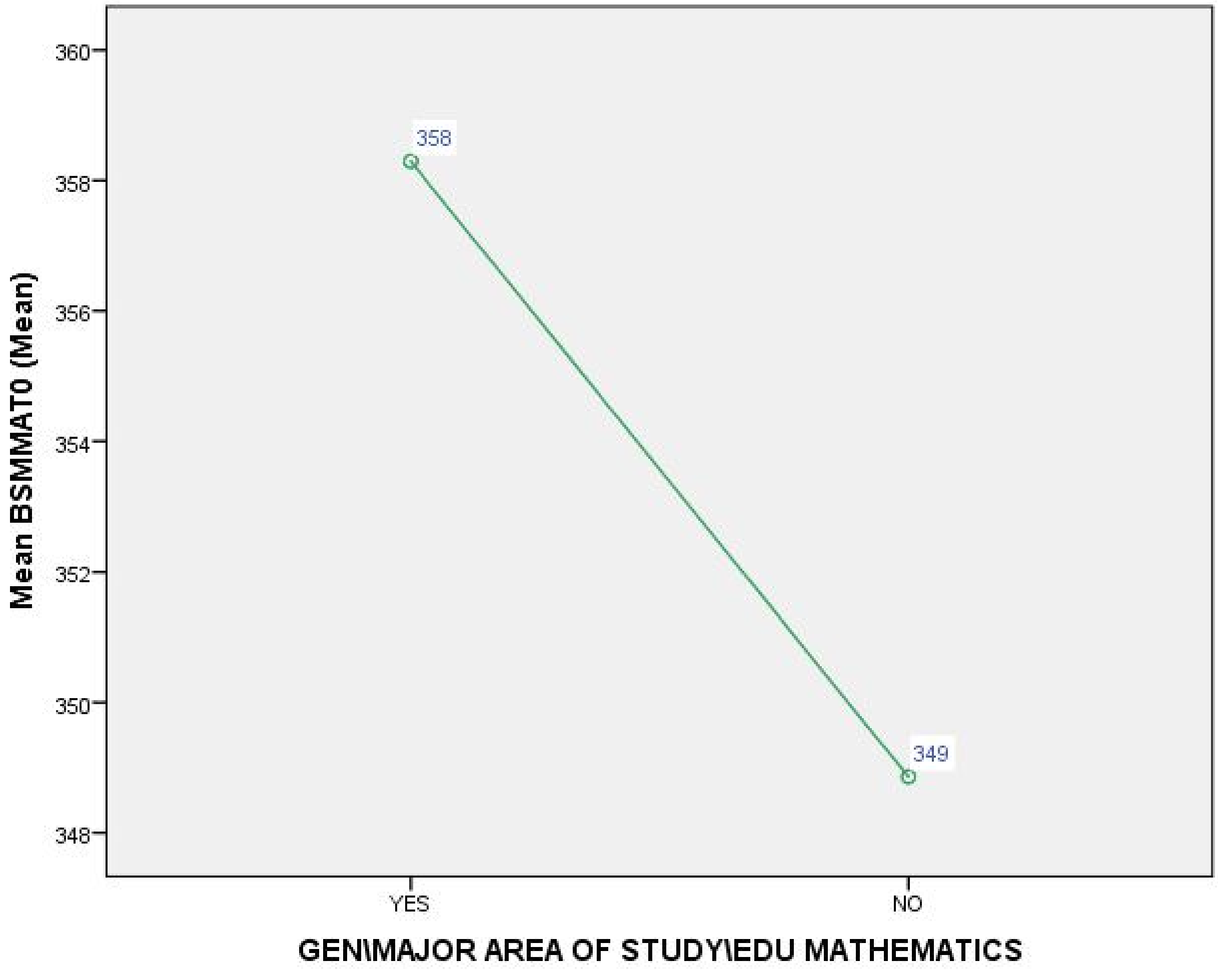
Summary of data: Significance in performance of learners taught by teachers with mathematics as major area of study

		Regression coefficient	**Regression coefficient (standard error)**	**Regression coefficient (t-value)**
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		364.66	10.85	33.62
BTBG05A_D1	Mathematics as major	-14.86	12.61	-1.18

2.3.2 Education mathematics as major

BTBG05F	dvar	n	pct	pct_se	mnpv	mnpv_se	sdpv	sdpv_se	vrpv	vrpv_se
YES	BSMMAT0	4,195	36.35	3.94	358.29	6.93	90.21	3.45	8,138.37	621.65
NO	BSMMAT0	6,617	63.65	3.94	348.86	4.10	85.02	2.76	7,228.93	468.42

Graphical representation of data: Mathematics as major vs average mathematics performance



Linear regression coefficient with dummy coding where D1 was the reference category.

Regression Coefficients

IDCNTRY	Variable	Regression Coefficient	Regression Coefficient (s.e.)	Regression Coefficient (t-value)	Stndrdzd. Coefficient	Stndrdzd. Coefficient (s.e.)	Stndrdzd. Coefficient (t-value)
South Africa	(CONSTANT)	348.86	4.10	85.14	.	.	.
	BTBG05F_D1	9.44	9.10	1.04	.05	.05	1.05
Table Average	(CONSTANT)	348.86	4.10	85.14	.	.	.
	BTBG05F_D1	9.44	9.10	1.04	.05	.05	1.05

Summary of data: Significance in performance of learners taught by teachers with education mathematics as major area of study

		Regression coefficient	**Regression coefficient (standard error)**	**Regression coefficient (t-value)**
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		348.86	4.10	85.14
BTBG05F_D1	Education Mathematics as major	9.44	9.10	1.04

2.4 Analysis of educational level and major areas of study vs learner performance

2.4.1 Mathematics as major vs learner performance

		GEN\MAJOR AREA OF STUDY\MATHEMATICS		Total
		YES	NO	
GEN\LEVEL OF FORMAL EDUCATION COMPLETED	<ISCED LEVEL 3>	165	36	201
	<ISCED LEVEL 4>	98	0	98
	<ISCED LEVEL 5B>	3 105	904	4009
	<ISCED LEVEL 5A, 1ST>	3 363	915	4278
	<ISCED LEVEL 5A, 2ND>	1 527	322	1849
Total		8 258	2177	10435

Summary of data: Level of Education vs Mathematics as major area of study

	Major area of study: Mathematics		**Total**
	Yes	**No**	
Matric	165	36	201
Post-matric certificate	98	0	98
Diploma	3 105	904	4 009
First degree	3 363	915	4 278
Hons+	1 527	322	1 849
Total	8 258	2 177	10 435

Linear regression coefficient with effect coding where E4 was the reference category.

Regression Coefficients

IDCNTRY	BTBG05A	Variable	Regression Coefficient	Regression Coefficient (s.e.)	Regression Coefficient (t-value)	Stndrdzd. Coefficient	Stndrdzd. Coefficient (s.e.)	Stndrdzd. Coefficient (t-value)
South Africa	NO	(CONSTANT)	389.6235	18.3610	21.2202	.	.	.
		BTBG04_E1	73.4240	.	.	.4403	.	.
		BTBG04_E3	-53.0342	22.7764	-2.3285	-.5272	.2241	-2.3520
		BTBG04_E5	-4.5605	25.2418	-.1807	-.0389	.2150	-.1807
	YES	(CONSTANT)	348.5896	4.4328	78.6395	.	.	.
		BTBG04_E1	7.9199	14.6293	.5414	.0475	.0857	.5537
		BTBG04_E2	-17.9005	7.9053	-2.2644	-.1033	.0452	-2.2826
		BTBG04_E3	-7.0764	8.1714	-.8660	-.0732	.0850	-.8614
		BTBG04_E5	9.7624	9.1957	1.0616	.0805	.0742	1.0846

Linear regression coefficient with effect coding where E5 was the reference category.

Regression Coefficients

IDCNTRY	BTBG05A	Variable	Regression Coefficient	Regression Coefficient (s.e.)	Regression Coefficient (t-value)	Stndrdzd. Coefficient	Stndrdzd. Coefficient (s.e.)	Stndrdzd. Coefficient (t-value)
South Africa	NO	(CONSTANT)	389.6235	18.3610	21.2202	.	.	.
		BTBG04_E1	73.4240	.	.	.3576	.	.
		BTBG04_E3	-53.0342	22.7764	-2.3285	-.4340	.1841	-2.3575
		BTBG04_E4	-15.8294	21.5308	-.7352	-.1349	.1853	-.7279
	YES	(CONSTANT)	348.5896	4.4328	78.6395	.	.	.
		BTBG04_E1	7.9199	14.6293	.5414	.0359	.0646	.5559
		BTBG04_E2	-17.9005	7.9053	-2.2644	-.0773	.0336	-2.3031
		BTBG04_E3	-7.0764	8.1714	-.8660	-.0573	.0663	-.8645
		BTBG04_E4	7.2946	6.5979	1.1056	.0601	.0546	1.1021

Summary of data: Learner results of teachers with mathematics as major area of study vs level of education

BTBG05A			**Regression coefficient**	**Regression coefficient (standard error)**	**Regression coefficient (t-value)**
	EqVar	**Label**	**b**	**b.se**	**b.t**
No	**(CONSTANT)**		**389.62**	**13.92**	**28.00**
No	BTBG05_E1	Matric	73.42	#NULL!	#NULL!
No	BTBG05_E3	Diploma	-53.03	18.62	-2.85***

BTBG05A			Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
	EqVar	**Label**	**b**	**b.se**	**b.t**
No	BTBG05_E4	Degree	-15.83	#NULL!	#NULL!
No	BTBG05_E5	Hons+	-4.56	22.22	-0.21
Yes	**(CONSTANT)**		**348.59**	**4.43**	**78.64**
Yes	BTBG05_E1	Matric	7.92	14.63	0.54
Yes	BTBG05_E2	Post-matric certificate	-17.90	7.91	-2.26***
Yes	BTBG05_E3	Diploma	-7.08	8.17	-0.87
Yes	BTBG05_E4	Degree	7.29	6.60	1.11
Yes	BTBG05_E5	Hons+	9.76	9.20	1.06

2.4.2 Education Mathematics as major vs educational level

		GEN\MAJOR AREA OF STUDY\EDU MATHEMATICS		Total
		YES	NO	
GEN\LEVEL OF FORMAL EDUCATION COMPLETED	<ISCED LEVEL 3>	158	43	201
	<ISCED LEVEL 4>	0	98	98
	<ISCED LEVEL 5B>	1476	2469	3945
	<ISCED LEVEL 5A, 1ST>	1685	2548	4233
	<ISCED LEVEL 5A, 2ND>	711	1099	1810
Total		4030	6257	10287

Summary of data: Level of Education vs Education Mathematics as major area of study

	Major area of study: Education Mathematics		Total
	Yes	**No**	
Matric	158	43	201
Post-matric certificate	0	98	98
Diploma	1 476	2 469	3 945
First degree	1 685	2 548	4 233

	Major area of study: Education Mathematics		Total
	Yes	No	
Hons+	711	1 099	1 810
Total	4 030	6 257	10 287

Linear regression coefficient with effect coding where E2 was the reference category.

BTBG05F	EqVar	b	beta	b.se	beta.se	b.t	beta.t
NO	(CONSTANT)	340.4659	#NULL!	3.4602	#NULL!	98.3940	#NULL!
NO	BTBG04_E1	-16.4517	-0.0203	8.1033	0.0111	-2.0302	-1.8212
NO	BTBG04_E3	-0.2063	-0.0011	#NULL!	#NULL!	#NULL!	#NULL!
NO	BTBG04_E4	18.3879	0.1074	6.8093	0.0390	2.7004	2.7541
NO	BTBG04_E5	8.0469	0.0356	8.8956	0.0385	0.9046	0.9256
YES	(CONSTANT)	359.2700	#NULL!	11.5088	#NULL!	31.2170	#NULL!
YES	BTBG04_E1	35.3832	0.0748	60.9591	0.0826	0.5804	0.9053
YES	BTBG04_E3	-18.8716	-0.0979	15.0175	0.0775	-1.2566	-1.2637
YES	BTBG04_E5	30.1078	0.1280	21.8826	0.0866	1.3759	1.4785

Linear regression coefficient with effect coding where E1 was the reference category.

BTBG 05F	EqVar	b	beta	b.se	beta.se	b.t	beta.t
NO	(CONSTANT)	340.4659	#NULL!	3.4602	#NULL!	98.3940	#NULL!
NO	BTBG04_E2	-9.7768	-0.0120	7.6973	0.0101	-1.2702	-1.1859
NO	BTBG04_E3	-0.2063	-0.0011	#NULL!	#NULL!	#NULL!	#NULL!
NO	BTBG04_E4	18.3879	0.1069	6.8093	0.0383	2.7004	2.7876
NO	BTBG04_E5	8.0469	0.0354	8.8956	0.0381	0.9046	0.9293
YES	(CONSTANT)	370.9248	#NULL!	12.0681	#NULL!	30.7359	#NULL!
YES	BTBG04_E2	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
YES	BTBG04_E3	-30.5265	-0.1792	13.6197	0.0842	-2.2414	-2.1286
YES	BTBG04_E4	-11.6548	-0.0725	#NULL!	#NULL!	#NULL!	#NULL!
YES	BTBG04_E5	18.4530	0.0908	17.9607	0.0810	1.0274	1.1211

Summary of data: Learner results of teachers with education mathematics as major area of study vs level of education

BTBG05F			Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
	EqVar	**Label**	**b**	**b.se**	**b.t**
No	**(CONSTANT)**		**340.47**	**3.46**	**98.39**
No	BTBG05_E1	Matric	-16.45	#NULL!	#NULL!
No	BTBG05_E2	Post-matric certificate	-9.78	7.70	-1.27
No	BTBG05_E3	Diploma	-0.21	#NULL!	#NULL!
No	BTBG05_E4	Degree	18.39	6.81	2.70***
No	BTBG05_E5	Hons+	8.05	8.90	0.90
Yes	**(CONSTANT)**		**370.92**	**12.07**	**30.74**
Yes	BTBG05_E1	Matric	23.73	45.30	0.52
Yes	BTBG05_E2	Post-matric certificate	#NULL!	#NULL!	#NULL!
Yes	BTBG05_E3	Diploma	-30.53	13.62	-2.24***
Yes	BTBG05_E4	Degree	-11.65	#NULL!	#NULL!
Yes	BTBG05_E5	Hons+	18.45	17.96	1.03

Combined table: Major areas of study

Level of formal education completed	Major area of study: Mathematics		Total	Major area of study: Education Mathematics		Total
	YES	NO		YES	NO	
Completed matric	3	1	4	3	1	4
Post-Matric certificate	2	0	2	0	2	2
Diploma	81	24	105	36	67	103
Degree	93	25	118	47	70	117
Hons+	42	11	53	22	30	52
Total	221	61	282	108	170	278

3 Teaching experience vs Learner performance

3.1 Development stages proposed by Katz

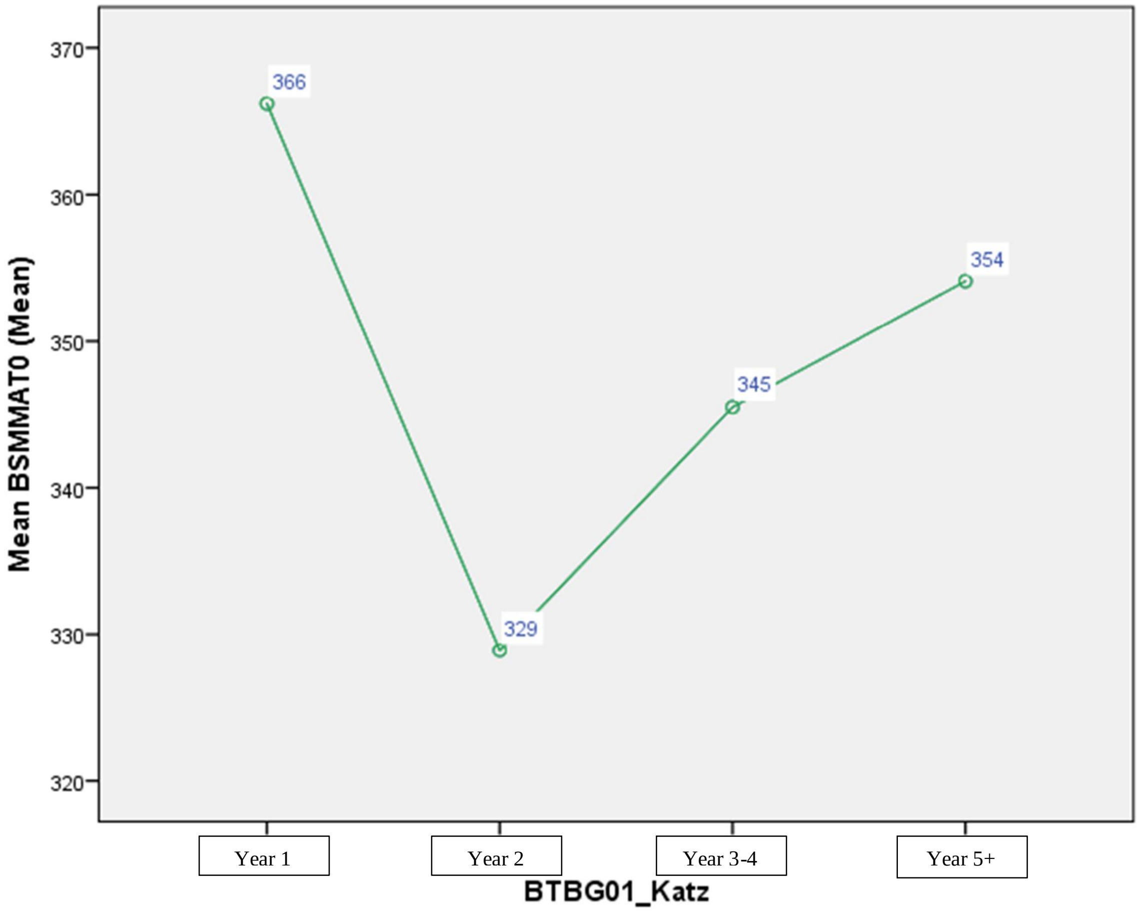
Number of learners, mean and se of pv's taught by teachers in each category of teacher development according to Katz

BTBG01_ Katz	dvar	n	pct	pct_se	mnpv	mnpv_se	sdpv	sdpv_se
1.00	BSMMAT0	319	3.55	1.41	366.20	23.64	83.20	10.12
2.00	BSMMAT0	466	4.44	1.56	328.91	22.02	90.77	20.12
3.00	BSMMAT0	1,264	11.27	2.49	345.49	9.61	86.00	8.01
4.00	BSMMAT0	8,839	80.75	3.10	354.11	3.71	86.50	2.36

Summary of data: Number of learners, mean and se of pv's taught by teachers in each category of teacher development

		Mean of plausible values	**Standard error of plausible values**
	N	**mnpv**	**sdpv**
Survival (Year 1)	319	366.20	83.20
Consolidation (Year 2)	466	328.91	90.77
Renewal (Year 3-4)	1 264	345.49	86.00
Maturity (Year 5+)	8 839	354.11	86.50
Total	10 888		

Graphical representation of data: Teacher development stages proposed by Katz vs mathematics performance



Linear regression coefficient with effect coding where E1 was the reference category.

EqVar	b	beta	b.se	beta.se	b.t	beta.t
(CONSTANT)	348.6788	#NULL!	8.2557	#NULL!	42.2350	#NULL!
BTBG01_KATZ_E2	-19.7720	-0.0644	17.8176	0.0595	-1.1097	-1.0822
BTBG01_KATZ_E3	-3.1841	-0.0138	10.5360	0.0456	-0.3022	-0.3032
BTBG01_KATZ_E4	5.4333	0.0311	9.7283	0.0564	0.5585	0.5519

Linear regression coefficient with effect coding where E2 was the reference category.

EqVar	b	beta	b.se	beta.se	b.t	beta.t
(CONSTANT)	348.6788	#NULL!	8.2557	#NULL!	42.2350	#NULL!
BTBG01_KATZ_E1	17.5228	0.0571	18.8133	0.0591	0.9314	0.9660
BTBG01_KATZ_E3	-3.1841	-0.0143	10.5360	0.0473	-0.3022	-0.3027
BTBG01_KATZ_E4	5.4333	0.0325	9.7283	0.0588	0.5585	0.5525

Summary of data: Significance in performance of learners taught by teachers in Katz' development stages

		Regression coefficient	Regression coefficient (standard error)	Regression coefficient (t-value)
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		348.68	8.26	42.23
BTBG01_E1	1 year	17.52	18.81	0.93
BTBG01_E2	2 years	-19.77	17.82	-1.11
BTBG01_E3	3-4 years	-3.18	10.54	-0.30
BTBG01_E4	5+ years	5.43	9.73	0.56

3.2 Development stages proposed by Huberman

Number of learners, mean and se of pv's taught by teachers in each category of teacher development according to Huberman

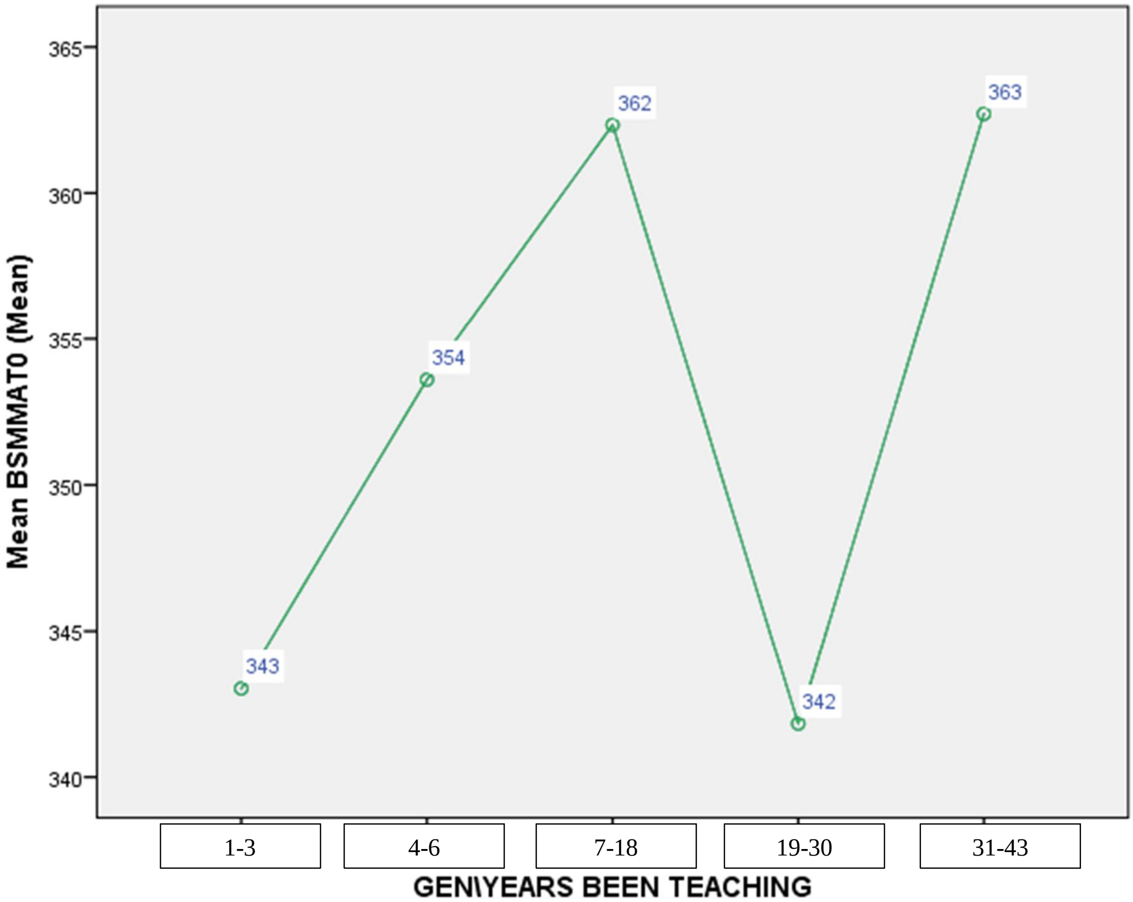
BTBG01	dvar	n	MATWGT	sumw_se	pct	pct_se	mnpv	mnpv_se	sdpv
1	BSMMAT0	1,458.00	110,904.29	22,757.94	12.76	2.62	343.03	11.11	87.71
2	BSMMAT0	1,515.00	126,332.73	25,011.07	14.53	2.80	353.60	8.16	85.35
3	BSMMAT0	4,397.00	330,225.79	34,702.33	37.98	4.15	362.33	6.62	89.43
4	BSMMAT0	3,111.00	261,484.68	38,149.73	30.08	4.08	341.83	6.98	83.74
5	BSMMAT0	407.00	40,423.77	13,784.55	4.65	1.57	362.71	15.87	73.38

Summary of data: Number of learners, mean and se of pv's taught by teachers in each category of teacher development

		Mean of plausible values	Standard error of plausible values
	N	**mnpv**	**sdpv**
Survival and Discovery (1-3)	1 458	343.03	87.71
Stabilization (4-6)	1 515	353.60	85.35
Experimentation/Diversification (7-18)	4 397	362.33	89.43
Conservatism/Serenity (19-30)	3 111	341.83	83.74

		Mean of plausible values	Standard error of plausible values
	N	mnpv	sdpv
Disengagement (31-43)	407	362.71	73.38
Total	10 888		

Graphical representation of data: Huberman's stages of teacher development vs mathematics performance



Linear regression coefficient with effect coding where E1 was the reference category.

EqVar	b	beta	b.se	beta.se	b.t	beta.t
(CONSTANT)	352.7004	#NULL!	3.9858	#NULL!	88.4891	#NULL!
BTBG01_E2	0.9014	0.0055	7.8369	0.0471	0.1150	0.1157
BTBG01_E3	9.6341	0.0740	7.5330	0.0577	1.2789	1.2828
BTBG01_E4	-10.8738	-0.0791	7.3561	0.0540	-1.4782	-1.4644
BTBG01_E5	10.0129	0.0472	13.2304	0.0621	0.7568	0.7606

Linear regression coefficient with effect coding where E2 was the reference category.

EqVar	b	beta	b.se	beta.se	b.t	beta.t
(CONSTANT)	352.7004	#NULL!	3.9858	#NULL!	88.4891	#NULL!
BTBG01_E1	-9.6745	-0.0582	10.3763	0.0635	-0.9324	-0.9163
BTBG01_E3	9.6341	0.0761	7.5330	0.0589	1.2789	1.2934
BTBG01_E4	-10.8738	-0.0814	7.3561	0.0559	-1.4782	-1.4560
BTBG01_E5	10.0129	0.0492	13.2304	0.0648	0.7568	0.7599

Summary of data: Significance in performance of learners taught by teachers in Huberman's development stages

		Regression coefficient	**Regression coefficient (standard error)**	**Regression coefficient (t-value)**
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		352.70	3.99	88.49
BTBG01_E1	1-3 years	-9.67	10.38	-0.93
BTBG01_E2	4-6 years	0.90	7.84	0.12
BTBG01_E3	7-18 years	9.63	7.53	1.28*
BTBG01_E4	19-30 years	-10.87	7.36	-1.48*
BTBG01_E5	31-43 years	10.01	13.23	0.76

3.3 Development stages proposed by Day

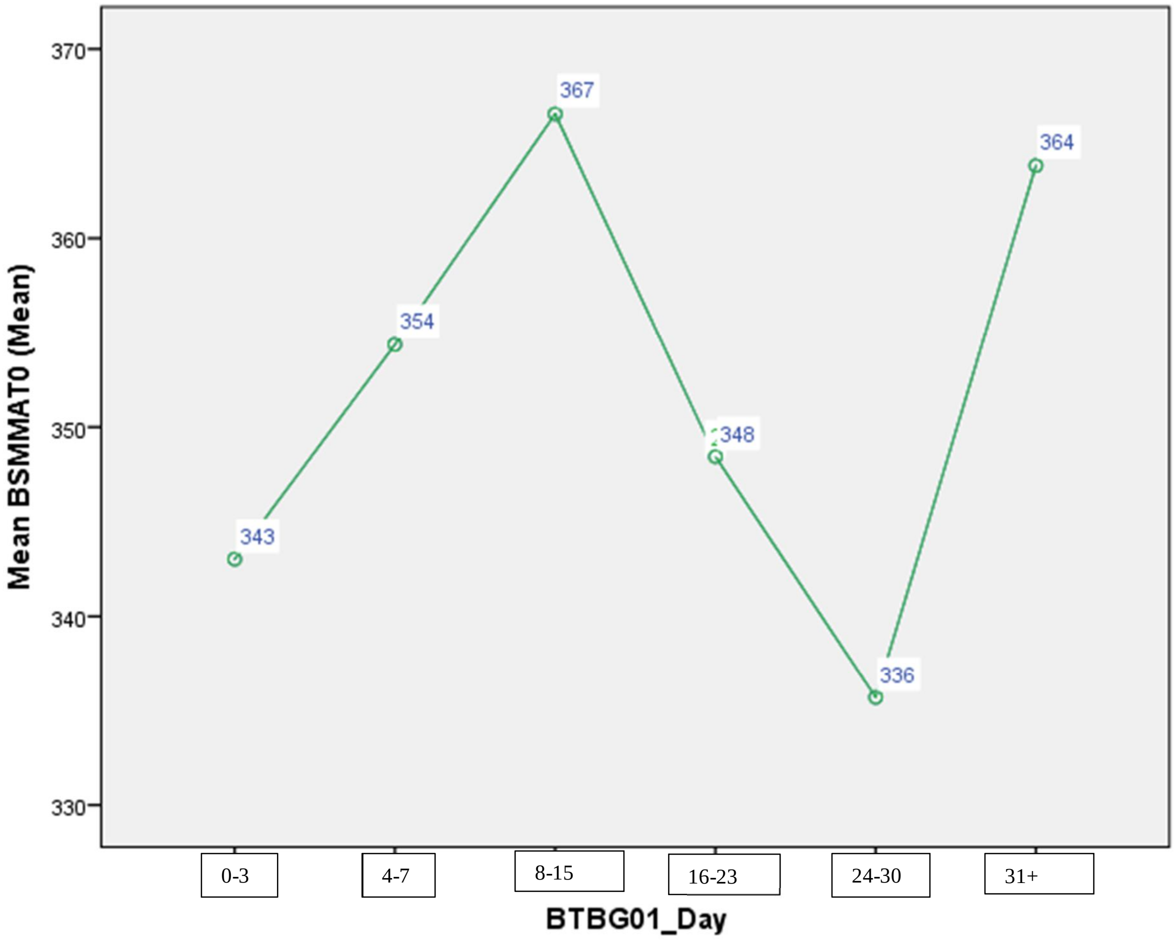
Number of learners, mean and se of pv's taught by teachers in each category of teacher development according to Day

BTBG01_ Day	dvar	n	pct	pct_se	mnpv	mnpv _se	sdpv
1.00	BSMMAT0	1,458	12.76	2.62	343.03	11.11	87.71
2.00	BSMMAT0	1,820	17.19	3.11	354.37	7.99	86.18
3.00	BSMMAT0	2,786	24.44	3.44	366.57	8.03	87.87
4.00	BSMMAT0	3,132	29.16	3.58	348.44	6.24	88.50
5.00	BSMMAT0	1,256	11.66	2.58	335.70	9.51	79.40
6.00	BSMMAT0	436	4.79	1.57	363.84	15.46	73.07

Summary of data: Number of learners, mean and se of pv's taught by teachers in each category of teacher development

		Mean of plausible values	**Standard error of plausible values**
	N	**mnpv**	**sdpv**
Commitment, support and challenge(0-3)	1 458	343.03	87.71
Identity and Efficacy in Classroom (4-7)	1 820	354.37	86.18
Managing Changes in Role and Identity, growing tensions and transitions (8-15)	2 786	366.57	87.87
Work-life Tensions, challenges to motivation and commitment (16-23)	3 132	348.44	88.50
Challenges to Sustaining Motivation (24-30)	1 256	335.70	79.40
Ability to cope with Change, Looking to Retire (31+)	436	363.84	73.07
Total	10 888		

Graphical representation of data: Day's stages of teacher development vs mathematics performance



Linear regression coefficient with effect coding where E1 was the reference category.

EqVar	b	beta	b.se	beta.se	b.t	beta.t
(CONSTANT)	351.9915	#NULL!	3.2954	#NULL!	106.8138	#NULL!
BTBG01_DAY_E2	2.3781	0.0150	7.8883	0.0495	0.3015	0.3029
BTBG01_DAY_E3	14.5766	0.1006	8.4110	0.0577	1.7331	1.7418
BTBG01_DAY_E4	-3.5505	-0.0256	5.8243	0.0424	-0.6096	-0.6050
BTBG01_DAY_E5	-16.2880	-0.0928	9.5687	0.0550	-1.7022	-1.6883
BTBG01_DAY_E6	11.8494	0.0562	13.4691	0.0633	0.8797	0.8873

Linear regression coefficient with effect coding where E2 was the reference category.

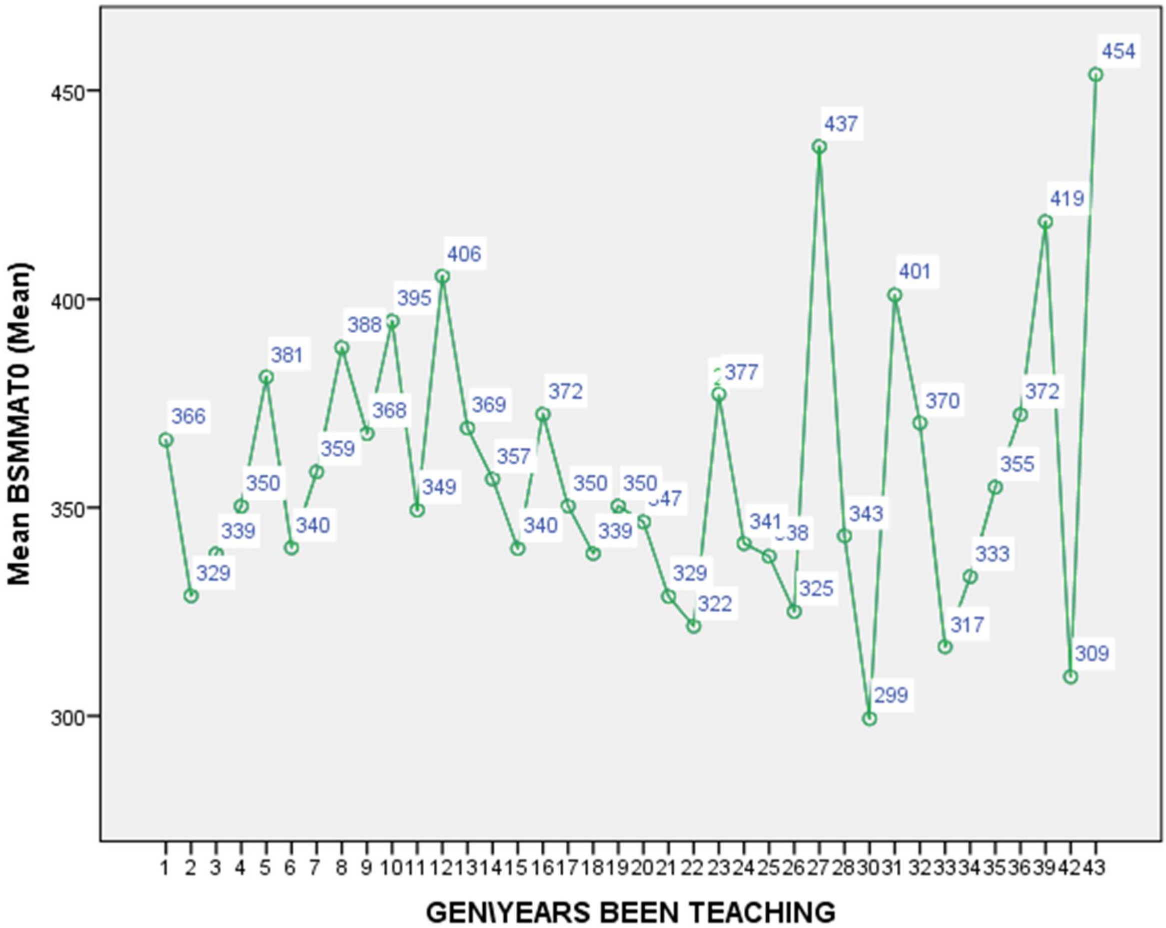
EqVar	b	beta	b.se	beta.se	b.t	beta.t
(CONSTANT)	351.9915	#NULL!	3.2954	#NULL!	106.8138	#NULL!
BTBG01_DAY_E1	-8.9656	-0.0563	10.7310	0.0684	-0.8355	-0.8241
BTBG01_DAY_E3	14.5766	0.1077	8.4110	0.0608	1.7331	1.7709
BTBG01_DAY_E4	-3.5505	-0.0274	5.8243	0.0452	-0.6096	-0.6072
BTBG01_DAY_E5	-16.2880	-0.1003	9.5687	0.0601	-1.7022	-1.6705
BTBG01_DAY_E6	11.8494	0.0617	13.4691	0.0698	0.8797	0.8841

Summary of data: Significance in performance of learners taught by teachers in Day's development stages

		Regression coefficient	**Regression coefficient (standard error)**	**Regression coefficient (t-value)**
EqVar	**Label**	**b**	**b.se**	**b.t**
(CONSTANT)		351.99	3.30	106.81
BTBG01_E1	0-3 years	-8.97	10.73	-0.84
BTBG01_E2	4-7 years	2.38	7.89	0.30
BTBG01_E3	8-15 years	14.58	8.41	1.73**
BTBG01_E4	16-23 years	-3.55	5.82	-0.61
BTBG01_E5	24-30 years	-16.29	9.57	-1.70**
BTBG01_E6	31+ years	11.85	13.47	0.88

3.4 Learner performance for every years of experience category

Graphical representation of data: Teaching experience vs average mathematics mark



4 Chi-Square tests

In terms of teacher numbers

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of GEN\SEX OF TEACHER occur with equal probabilities.	One-Sample Chi-Square Test	.203	Retain the null hypothesis.
2	The categories of GEN\LEVEL OF FORMAL EDUCATION COMPLETED occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.
3	The categories of GEN\MAJOR AREA OF STUDY\MATHEMATICS occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.
4	The categories of GEN\MAJOR AREA OF STUDY\EDU MATHEMATICS occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.
5	The categories of GEN\AGE OF TEACHER occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

In terms of learner numbers

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of GEN\SEX OF TEACHER occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.
2	The categories of GEN\AGE OF TEACHER occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.
3	The categories of GEN\LEVEL OF FORMAL EDUCATION COMPLETED occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.
4	The categories of GEN\MAJOR AREA OF STUDY\MATHEMATICS occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.
5	The categories of GEN\MAJOR AREA OF STUDY\EDU MATHEMATICS occur with equal probabilities.	One-Sample Chi-Square Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

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