SCHOOL MATHEMATICS PERFORMANCE: A LONGITUDINAL CASE STUDY

by

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DECLARATION

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I, Wendy Stone, hereby declare that I have edited the MEd thesis *School Mathematics Performance: A Longitudinal Case Study* by Deborah Fair.

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DEDICATION

This thesis is dedicated to my parents,
Kenneth Jeremiah and Jennifer Ann,
in gratitude for their unconditional love.

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ABSTRACT

In South African schooling, two sectors exist in which 75% of schools achieve significantly lower than the upper 25% of schools, resulting in a bimodal education system. However, the level of mathematics performance of South African learners from schools of all quintiles is far below international standards. There is a dearth of longitudinal studies investigating mathematics performance and it appears as though none have been done on South African learner performance in mathematics from Grade 1 to 12. The aim of this study was to investigate the mathematics performance from Grade 1 to 12 of boys attending a South African ex-Model C, single-gender school. A two-pronged approach was used. Firstly, the mathematics performance of learners who took Mathematics up to Grade 12 was compared to that of those who opted for Grade 12 Mathematical Literacy instead. Secondly, the effectiveness of mathematics performance in lower grades in predicting that in subsequent grades was investigated.

In order to do so, the promotion marks of learners in eight consecutive cohorts (Grades 1 to 12) at the same school were used. Archived data were retrieved from SA-SAMS and the school's hardcopies of learners' results. Learners matriculating at the school in either Mathematics or Mathematical Literacy were separated into a Mathematics-set (M-set) (n=302) or a Mathematical Literacy set (ML-set) (n=160) respectively. The "Proc Mixed" procedure was used to analyse the data. The Mixed Model for Repeated Measures (MMRM) with an unstructured covariance matrix for repeated measures within learners was fitted, using Restricted Maximum Likelihood (REML), fitting fixed effects of cohort, grade and grade within a cohort. Regression analysis was performed to establish correlations and thus the precision with which current grade marks predict future grade marks. Ryan and Deci's Self-Determination Theory and Piaget's Cognitive Theory were useful in providing possible explanations for the results.

The mathematics performance of the two sets from Grade 1 to 7 followed a similar trend, but on average, the M-set performed 10% better than the ML-set. Mathematics performance was stable in the Foundation Phase. While national results generally reflect a decrease in marks from Grade 3 to 4, the learners in the current study showed an increase in mean marks. There

was a decline in mean marks in Grade 6, which had the weakest correlations with those in other grades than any other grades with one another. The highest mean mark for Mathematics (across all grades) was in Grade 7. The steepest decline in mean marks was from Grade 7 to 9; however, the ML-set experienced a much greater decline, causing the gap between the two sets to widen to 22%.

The implications arising from these results are numerous. For instance, the ML-set achieved mean marks that were below those of the M-set. The set that started out lower in Grade 1 ended lower in Grade 7. This underscores the importance of learners starting formal education in the strongest position possible as this trajectory is generally maintained throughout their schooling. Contrary to national averages, the mean marks increased from Grade 3 to 4. The learners' minimum of four years' exposure to English, as the LOLT, prior to Grade 4 could account for this. The decline in mean marks from Grade 7 to 9 coincides with other simultaneously occurring factors, namely puberty, the transition to high school and the introduction of more abstract concepts such as algebra. Learners in the Senior Phase face many difficulties and adjustments. It is in the interest of the learners' education that they are supported and guided, especially during these changes.

Key terms: *Mathematics, Mathematical Literacy, longitudinal, performance, self-efficacy, self-concept, adolescence, Self-Determination Theory, Piaget, curriculum, predict, subject choice*

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LIST OF ABBREVIATIONS

CAPS	Curriculum Assessment Policy Statement
DoE	Department of Education
FET	Further Education and Training
LOLT	Language of Learning and Teaching
LSM	Least Squares Means
MAR	Missing at random
ML-set	Group of learners who took Mathematical Literacy in Grade 12
MMRM	Mixed Model for Repeated Measures
M-set	Group of learners who took Mathematics in Grade 12
NCS	National Curriculum Statement
REML	Restricted maximum likelihood
RNCS	Revised National Curriculum Statement
SDT	Self-Determination Theory
UN	Unstructured

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

This study focuses on the longitudinal performance in mathematics of learners at an ex-Model C school. A Model C school was one under the apartheid government in South Africa that was attended by white learners only. This separation of white learners from the rest of the population resulted in two distinct standards of education. A bimodal education system continues to exist in South Africa, where one sector, consisting largely of previously whites-only schools, including the one under investigation, achieves significantly better results than the larger, poorly-performing sector attended almost exclusively by non-white learners. While a series of post-apartheid governments has attempted to equalise education across the board, especially in lower-performing schools, this has not happened (Pournara, Hodgen, Adler & Pillay, 2015; Spaull & Kotze, 2015). Moreover, both sectors achieve below international standards, prompting the need for research on the higher-performing schools. This chapter provides some background regarding this situation and describes the rationale, problem and purpose of this research, as well the context in which this study has taken place.

1.2 BACKGROUND INFORMATION

There is a vast difference between the two aforementioned schooling sectors in South Africa. Not only does the quality of education differ, but also the level of achievement of learners (Spaull, 2013a). The low-quintile (Quintiles 1-3) schools, which are no-fee schools (Department of Education, 2004), consistently achieve far below the high-quintile (Quintiles 4 and 5) schools, resulting in a dualistic education system in South Africa (Van der Berg, Taylor, Gustafsson, Spaull & Armstrong, 2011; Spaull, 2013a). Although Quintile 4 schools fall on the cusp between these two quintile groups with some of these schools underperforming, Quintile 5 schools are generally considered to be the best-resourced and top-performing schools in the country (Department of Education, 2004).

Due to factors such as the history of resistance to the education offered during apartheid along with aspects, such as a lack of equipment, poverty, low level of education of parents and teacher absenteeism, 70-75% of schools are still recovering from the breakdown in learning culture (Spaull, 2013a). These schools all grapple with similar issues, such as English (often the language of learning and teaching) not being spoken frequently at home, poorer home environments, lower education levels of parents and limited resources (Spaull, 2013a; Reddy, Juan & Meyiwa, 2013). All of this has contributed to the education provided being well below the standard required by the Department of Basic Education (DBE) and learners at these schools performing poorly (McCarthy & Oliphant, 2013).

By contrast, ex-model C schools are equipped with more resources, parents pay school fees, there is a low teacher-pupil ratio, low teacher absenteeism and discipline is predominantly well maintained. While the standard of education in these schools is of a relatively good quality (Yamauchi, 2011), these schools, which make up approximately 25-30% of the schools in South Africa, still perform far below global standards (Reddy et al., 2016).

Given the disparate nature of the education provided in these two schooling sectors, the conclusions arrived at from studying an ex-Model C school are not necessarily applicable to low-quintile schools (Reddy et al., 2013; Spaull, 2013a). Furthermore, Spaull (2013a) found that factors contributing to learner performance differ significantly in high- to low-quintile schools. He found that only five out of 27 factors affecting mathematics performance were common to both sectors and concluded that unifying data from both sectors, instead of distinguishing between the two, could jeopardise good policy-making decisions. It is therefore important that these two groups be researched independently to obtain a true understanding of South Africa's educational system and to recommend appropriate educational interventions (Reddy et al., 2013). However, this does not mean that research findings obtained from studying one sector necessarily have no relevance to the broader population of South African learners. Thus, although the present study also has the potential to provide useful information that can be used to enhance education in low-quintile schools, it should not be assumed that this is necessarily the case.

1.3 RATIONALE

The motivation for this research is threefold. Firstly, it is grounded in the researcher's personal perspective and range of teaching experience; secondly, the dire state of mathematics education in South Africa; and, thirdly, the lack of quantitative longitudinal school mathematics research.

1.3.1 Personal Perspective

The researcher has six years' teaching experience in the Foundation Phase and subsequently taught Mathematics and Mathematical Literacy in the Senior and Further Education and Training (FET) Phases respectively. During this time, there appeared to be similarities between the relative performance levels of learners who had been taught previously in the Foundation Phase and their levels of performance in Grades 7 to 12. The researcher was curious to establish whether there were any patterns in the mathematics performance of learners as a group over time, and to determine the correlations between mathematics performance in lower and subsequent grades.

1.3.2 South African Mathematics Education

The mathematics performance of learners in South Africa does not compare favourably with that of learners in other countries (McCarthy & Oliphant, 2013; Reddy, et al., 2016). This long-standing record of poor achievement in Mathematics has been highlighted by the results from studies such as the Grade Six Systemic Evaluation. International research, in the form of Trends in International Mathematics and Science Study (TIMSS) and Southern and Eastern Africa Consortium for Monitoring Education Quality (SACMEQ), have also painted a dismal picture of South African mathematics performance (Taylor, Fleisch & Shindler, 2008).

Fleisch (2008) asserts that South Africa's record of underperformance in Mathematics is of particular concern in primary education. In 2005, the DoE assessed Grade 6 learners by means of the Grade Six Systemic Evaluation, the results of which showed that only 12 per cent of learners achieved above 60% (levels 3 or 4). At that stage, over 80% of learners in South Africa did not achieve the standard required for Mathematics by the National Curriculum Statement (Fleisch, 2008). Hungi et al. (cited in Van der Berg, Spaull, Wills, Gustafsson & Kotze, 2016) found that 68% of South African Mathematics teachers lacked adequate mathematical knowledge, while research by Venkat and Spaull (2015) established that 79% of Grade 6 teachers have mathematical knowledge below Grade 6 level.

TIMSS involves assessing Grades 4, 8 and 12 Mathematics and Science learners globally, every four years (Weil & Taylor, 2015). The first TIMSS research was done in 1995, with TIMSS-Repeat (TIMSS-R) taking place in 1999. The TIMSS-R Grade 8 test proved too challenging for South African Grade 8 learners (Howie, 2004). Subsequently, TIMSS 2003 was administered to both Grades 8 and 9 learners (Spaull & Kotze, 2015). Again, Grade 8 learners found this test too difficult and, as a result, TIMSS 2011 was administered to Grade 9 learners only (Spaull & Kotze, 2015). The South African sample for the TIMSS study still consists of Grade 9 rather than Grade 8 learners. Despite the older South African learners competing against their younger counterparts in other countries, South Africa has remained in the bottom end of the results table.

In TIMSS 2011, in which South Africa was compared with 20 other middle-income countries, South Africa ranked last (Spaull, 2013b; Spaull & Kotze, 2015). A similar result was achieved in 2015 when Grade 5 learners in South Africa were being compared to Grade 4 learners internationally and yet ranked second-to-last to Saudi Arabian learners. At Grade 9 level, South African learners attained a Mathematics score of 372 (SE4.5) and ranked 38th out of 39 countries (Reddy et al., 2016). In addition, Reddy et al. (2016) indicate that the more affluent schools, namely Quintiles 4 and 5 and the Independent schools, making up 35% of the TIMSS sample, obtained scores of 423 and 477 respectively, and thus did not reach the centre-point score of 500. This demonstrates that even the top schools in the country perform relatively poorly when viewed against international standards.

Another comparison between countries compares the percentages of top achievers in TIMSS. One of the ways in which the results from TIMSS is reported is in the form of categories, with "Advanced" (625<Score) referring to the highest performers internationally and "High

level" (550-625) to the second-highest performers. The South African learners in TIMSS 2015, who were in the "Advanced" category, only made up 1% of South African learners while 3% were in the "High level" category. On the other hand, 54% of Singaporean learners, 43% of South Korean learners and 14% of learners from the Russian Federation achieved "Advanced" status. In South Korea and the Russian Federation, 32% of the learners achieved "High level" status (Letaba, 2017). These results confirm the need for research on South African learners who form this top-end group, as many South African learners do not meet top international Mathematics standards. Therefore, further research could assist in establishing the various reasons for there not being more learners in these two top categories.

The results of TIMSS 2011 also showed that of all the participating countries, South Africa had the widest distribution of scores in Mathematics, confirming that South African schools are heterogeneous and that a single aggregate score is misleading (Reddy et al., 2013). These researchers insist that a disaggregation of achievement scores into pertinent categories is essential for the meaningful analysis of Mathematics. Spaull (2013a) concurs with Reddy et al. (2013) and reveals that the tendency of some education research to pool all statistics (lumping the top 25-30% of higher-achieving schools with the 70-75%, which have a considerably lower mean achievement score), results in a skewed impression of the actual situation. Despite these averages being misleading, national and provincial averages are the main measure of performance used in government reports. Spaull (2013a:4) adds that "the 'average' South African learner does not exist in any meaningful sense," confirming the need for research that separates the two contrasting groups in the South African education system.

In an effort to minimize variables, such as poverty and low levels of education, it was decided in the present study to work only with a well-resourced, stable school that was achieving relatively good marks from the same quintile. This would allow the focus to be solely on learners at the various stages of development in the Mathematics curriculum rather than on poverty, education level of parents and other extenuating factors. In addition, Reddy et al. (2013) assert that attending to and supporting historically high-performing schools develop and expand the base of these types of schools in South Africa.

1.3.3 Quantitative Longitudinal Study

There is a lack of large-scale quantitative research in South Africa (Venkat, Adler, Rollnick, Setati & Vhurumuku, 2009), particularly in the field of longitudinal studies pertaining to mathematics performance (Pournara, Hodgen, Sanders & Adler, 2016). Jordan, Kaplan, Ramineni and Locuniak (2009) affirm that few studies have researched the strength of correlations between earlier and later grades when mathematical concepts become more complex.

This large-scale, longitudinal case study, spanning 19 years, provides much-needed information regarding learner performance in Mathematics (and Mathematical Literacy) in South Africa. This could provide considerable insight into the extent to which earlier Mathematics performance affects subsequent achievement in this subject (and in Mathematical Literacy). In the event of there being any strong correlations, this could underpin the importance of what is done in the lower grades to improve outcomes later in learners' schooling. For example, this additional knowledge could assist with early intervention strategies in primary school and subject choices at the end of Grade 9.

In high school, for example, if a significant correlation exists between Mathematics marks in Grades 9 and 10 or Grades 9 and 12, this information could be used to inform parents and learners when choosing between Mathematics and Mathematical Literacy in the FET Phase. If a successful model results from this study, knowledge may be increased (Hofstee, 2015), especially regarding mathematics performance over time. It is against this backdrop that a description of the school used in this study follows.

1.4 DESCRIPTION OF EX-MODEL C SCHOOL

The school under study is a highly-functional, ex-model C, boys' school. This 155-year-old Anglican school is situated in a leafy city suburb. It has a deep-seated history of high academic achievement and a culture of learning is staunchly encouraged. As a result of this, as well as various other factors, there has been 100% pass rate in Grade 12 for the past 25 years, and this Quintile 5 school is only one of three government boys' schools in South

Africa with a 100% matric pass rate for the past five years. There is strong support from the Old Boys' Association that, together with a large percentage of parents paying school fees, allows the school to be well resourced. Half of the teaching staff is funded by the school rather than by the government. The extra staffing has allowed the school to be known for its small class sizes, currently ranging from four to 30 (occasionally up to 36) learners, which is very similar to the class sizes to which the present study relates. Due to the changing political landscape in South Africa and pressure placed upon the school to accept more learners, the numbers at the school doubled during the period of this study, to 750 learners in 2016.

1.5 RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

The main objective of this study was to determine the mathematics performance profile of learners from Grade 1 to 12. For those who opted for Mathematical Literacy after Grade 9, their performance in this subject was also investigated. This was done by determining whether any significant correlations existed between learners' mathematics performance over their twelve-year period of schooling. Where moderately strong to strong correlations were found to exist, the predictive nature of these results was explored. The ability to predict a future mark with a relatively high level of precision could assist with the subject choice between Mathematics and Mathematical Literacy at the end of Grade 9, as well as highlight the need for early intervention if required. As a result, the following research questions were formulated to guide the focus of this research:

Primary research question: What is the longitudinal profile of mathematics performance of boys attending a South African ex-Model C, single-gender school?

Secondary research questions:

- How does mathematics performance change through the course of schooling for learners who take Mathematics to Grade 12 as opposed to that of those who take Mathematical Literacy?

- How effectively does learners' mathematics performance in lower grades predict their mathematics performance in higher grades?

1.6 PROBLEM STATEMENT

Educators and parents regard mathematics as an important subject. Yet there is a lack of research pertaining to mathematics in South African schools, especially primary school Mathematics (Adler, Ball, Krainer, Lin & Novotna, 2005). As far as could be ascertained, reporting a longitudinal study of correlations in mathematics performance of a group of South African learners from Grade 1 to 12, is unprecedented. A longitudinal study on mathematics performance such as this could therefore be beneficial in terms of addressing this gap in the education literature. The objective nature and relatively large scale of this study makes its application to other ex-Model C boys' schools probable and is likely to raise similar issues as far as girls' performance in mathematics is concerned. The findings may also shed light on mathematics performance across grades and improve the understanding of trajectories in mathematics performance, which could enrich other related research.

1.7 RESEARCH APPROACH

The research undertaken in this study was quantitative in nature and included data collected from archives. The data consisted of the Grades 1 to 12 annual promotion Mathematics and Mathematical Literacy marks of learners from eight different cohorts who attended the school from 1998 to 2016. The data were analysed, fitting a Mixed Model for Repeated Measures (MMRM), which was fitted, using Restricted Maximum Likelihood (REML) tests for significance. Two data sets were established, namely a Mathematics set (n=302), consisting of the data of learners who took Mathematics in Grade 12, and a Mathematical Literacy set (n=160), consisting of the data of learners who opted for Mathematical Literacy in matric. This study is positioned in the post-positivist paradigm because, unlike the positivist approach, which assumes that certainty can be established through objective investigation, the post-positivist paradigm acknowledges the presence of subjectivity in research. This is particularly appropriate in this study since deductions made from the quantitative data analysis were tentatively explained (Mertens, 2010) in terms of the literature, without empirical evaluation of these explanations falling within the scope of the study.

1.8 DELINEATION, LIMITATIONS AND ASSUMPTIONS

1.8.1 Delineation

This study focuses on the trends in school mathematics performance over time, the correlations between grades and the effectiveness of predicting later grade marks, using those obtained in earlier grades. The researcher did not attempt to test or isolate specific subskills (such as counting or knowledge of fractions) that may or may not have been mastered, and which could have affected the learners' level of performance. While factors, such as teachers' mathematical content knowledge (Venkat & Spaull, 2015), gender differences (Penner & Paret, 2008; Wei, Liu & Barnard-Brak, 2015), basic underlying skills (LeFevre et al., 2010) and early intervention (McCarthy & Oliphant, 2013; Mononen & Aunio, 2016) influence learner performance, the aim of this study was not to conduct empirical research into these factors or to determine the extent to which they have an impact. The curricula of other countries where research had been done were not assessed or compared with South African curricula.

1.8.2 Limitations

Several limitations arise from the fact that only this school was researched, and that archived data were used. The data collected were only from learners from this high-quintile school. The results and conclusions can be related to ex-Model C Quintile 5 schools. However, applying the conclusions from this research to low-quintile schools must be done with caution as this work does not consider factors, such as poverty at home, over-crowded classrooms and lack of school resources, which affect a large number of learners at low-quintile schools (Fleisch, 2008; (Spaull & Kotze, 2015). Furthermore, differences between the genders, particularly related to puberty, reduce the applicability of the findings of this study to schools which include girls.

In some of the earlier grades referred to in the study, promotion marks were only recorded as levels. As a result, the midpoints were calculated instead of an actual percentage being used in the data set. A promotion mark was ascertained for every grade in which a learner was enrolled at the school. However, several values were missing from the dataset as not all learners attended the school for their entire schooling. Multiple imputations (MI) were used to impute missing data and an MMRM was fitted (Krueger & Tian, 2004) to reduce this limitation.

The various assessments focused on different learning areas and not all tests, exams or other forms of assessment used were standardised. Although the teachers employed at this school generally deliver a similarly high standard of teaching, the standard of teaching could not be assessed. This limitation was reduced by class visits and teacher file and learner book control by the principal and heads of department. This relative consistency of standard would increase the likelihood of comparability regarding the standard of teaching and assessment among teachers.

1.8.3 Assumptions

In order to make claims with a degree of generalisability to other contexts, it is assumed that all teaching and assessment was of a similar standard and that the assessments were executed, and the marks reported in a professional, unbiased manner to the best of each teacher's ability. Based on the researcher's knowledge and experience of the quality of teacher this school employs and of most of the individual teachers' standard of teaching, as well as the fact that moderation and quality control policies are enforced at this school, this assumption appears reasonable. However, it was impossible to assess this assumption rigorously as some teachers are no longer at the school. Moreover, while teachers were assessed quarterly in various ways, a record thereof was not kept in the archives.

1.9 THESIS OVERVIEW

This chapter provided the background and rationale of this study, with a description of the current condition of mathematics performance in South Africa and the bimodal state of mathematics performance, which requires that both lower- and higher-achieving schools be researched. Additionally, a summary was given of the research objectives and methods used in this study along with its delineation, limitations, abbreviations and assumptions. The following chapter (Chapter 2) focuses on various perspectives found in the literature regarding curricula, the cognitive development of learners, as well as psychological and affective factors affecting academic performance. This is followed by a discussion on mathematics performance and the effectiveness of predicting later marks based on earlier results. Chapter 2 concludes with a discussion on adolescence in general and the transition to high school.

Chapter 3 comprises the theoretical framework of this study and outlines Ryan and Deci's Self-Determination Theory and Piaget's Cognitive Theory both of which provide in-depth platforms for discussion. Chapter 4 discusses the research design and instruments employed in this study, after which an explanation of how the data were obtained and edited before analysis, is provided. This chapter concludes with a description of how the data were analysed as well as an account of the ethical considerations adhered to.

Chapter 5 is divided into three main sections, the first of which examines the M-set while the second considers the ML-set, and the third compares the two. Chapter 6 constitutes an investigation into the correlation between mean Mathematics and Mathematical Literacy marks and the prediction of mean marks in subsequent grades, using those from earlier grades. Chapter 7, the final chapter of this thesis, provides a summary of the results and their implications, as well as the conclusions reached and recommendations for further research.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

This literature review, which covers a wide range of topics, begins with a brief discussion of the historical background of the curricula linked to this study. Thereafter, descriptions of the cognitive development of learners and adolescence are provided. Various psychological and affective factors influencing learners' academic performance are elaborated upon. This is followed by an elucidation of the inevitable transition to high school with its associated challenges. The focus then shifts to mathematics performance over time where various longitudinal and other studies are examined. The chapter concludes with a discussion on earlier achievement predicting subsequent achievement.

2.2 CURRICULA

2.2.1 Historical Background

This study examines various curricula, starting with Curriculum 2005 (C2005), which was implemented in 1998 and revised in 2000. Later, it was termed the National Curriculum Statement (NCS) and applied in 2001 (Van Deventer, 2009). The NCS underwent revision and was replaced by the Revised National Curriculum Statement (RNCS) in 2004. In 2012, the Curriculum Assessment Policy Statement (CAPS) was implemented and is still in use.

2.2.1.1 Curriculum 2005

During the apartheid era, which ended in 1994, racial segregation was in place. During this time, white learners were significantly advantaged at the cost of the education of black learners (Taylor et al., 2008). After 1994, the African National Congress (ANC) government brought about a major transformation in education by introducing the outcomes-based

Curriculum 2005, which was implemented in 1998 by the Department of Education (DoE) (Venkat et al., 2009; Van Deventer, 2009).

Some of the characteristics of this curriculum included the role of the educator shifting to that of facilitator and activities becoming more learner-centred. Learners were meant to construct their own meaning by engaging in sense making while teachers facilitated the process. Rather than merely pouring information into learners' heads, teachers were meant to guide the learners through the process of self-discovery. The intention was also that learners would work at their own pace. Various forms of assessment were used to evaluate the learners, and this continuous assessment was done by the facilitator (teacher), although peer- and self-assessment were also possible (Rault-Smith, 2013; Grussendorff, Booyse & Burroughs, 2014).

This curriculum was, by no means, perfect and was criticised by Christie (1999), Schmidt and Datnow (2005), Spreen and Vally (2006) and Reddy et al. (2013) for the following reasons:

- Teachers lacked knowledge regarding the implementation of the curriculum (partly due to the hasty introduction thereof);
- Real procedures and measures to solve multifaceted systemic challenges were not put in place;
- Resistance to the curriculum was evident; and
- A learning area such as Mathematics, known as Mathematical Literacy, Mathematics and Mathematical Sciences (MLMMS), included general numeracy, arithmetic, mathematics and statistics. The scope was rather loosely stated with the expectation that teachers would make the necessary adjustments to accommodate their and learners' interests and local contexts.

Due to these and other failings, C2005 neglected to meet the intellectual requirements of learners and was then replaced by the RNCS.

2.2.1.2 National Curriculum Statements and the Revised National Curriculum Statements

In an attempt to make C2005, with its outcomes-based approach, less vague and more efficient, it was revised in 2000 and became known as the NCS. This was later replaced by the RNCS, which was introduced in phases from 2004 (Department of Education of South Africa, 2002). According to Reddy et al. (2013), the RNCS was a great improvement and offered a pertinent and more challenging curriculum.

2.2.1.3 Curriculum and Assessment Policy Statement

The CAPS curriculum is not considered an entirely new curriculum but rather an adaptation of the RNCS as the changes from the RNCS are not extreme. One important difference is that the RNCS was more participatory and learner-centred whereas the CAPS curriculum is more teacher-centred. The current curriculum is also more content driven. Grussendorff et al. (2014) assert that there is a higher level of specification of content and that the pace of the CAPS curriculum is faster. In CAPS, there is a more obvious progression in terms of content and ability across the grades than was evident in the RNCS. Although a positive feature of CAPS is the clear vertical alignment of terminology, content and skills within Mathematics, there is less expectation that concepts be applied to everyday life (Grussendorff et al., 2014). When it comes to Mathematics, specifically, there was a 15% increase in the breadth of the FET curriculum and a significant increase in the depth of the overall curriculum.

2.3 DEVELOPMENT OF LEARNERS

2.3.1 Cognitive Development

The emphasis by various researchers on that which affects children's development and learning has varied over the decades. Piaget developed his Cognitive Theory (Huitt & Hummel, 2003; Ojose, 2008) to explain the development and learning of children based on cognition while Flavell (cited in Newton & Alexander, 2013), who supports Piaget's theory, maintains that individual variability plays a role in learning. Newton and Alexander (2013) assert that there are researchers who focus on the everyday, socially-supported cognitions occurring within communities instead of the development of the individual mind and yet still consider Piaget's Cognitive Theory as having value. (Piaget's theory is discussed in detail in Chapter 3.)

There is a close association between the physiological development of the brain and the changes in cognition as an individual matures. This is examined more closely in the following section. Firstly, learners in the Foundation Phase are considered and, secondly, cognition and brain development in adolescents is discussed.

In the Foundation Phase, learners are generally very optimistic as far as their ability to master a skill is concerned. Their skills base increases quite rapidly, which helps to drive this expectation of success despite initial failure (Eccles, 1999). Young learners develop important numerical skills in a step-wise fashion as each concept builds on previously-learnt concepts. The type of concepts and processes become more intricate and abstract as the child progresses through school (Fritz, Ehlert & Balzer, 2013).

Once early adolescence is reached, several significant cognitive changes occur. Young adolescents are progressively more able to think abstractly and distinguish between what is hypothetical and what is real (Keating, 2004). They are also increasingly able to ponder various aspects of a problem simultaneously and can apply their knowledge as different learning situations arise. According to Eccles (1999), young adolescents are also more aware of their strengths and weaknesses and become increasingly able to self-regulate in order to tackle more challenging tasks. Wigfield, Lutz and Wagner (2005) affirm that the increasing ability to organise and reflect allows these learners to engage in higher-order thinking, resulting in improved reasoning and decision making. The prefrontal cortex matures fully towards the end of late adolescence, which according to Wigfield et al. (2005), could account for these changes in cognition. As brain development influences cognition, and cognition affects behaviour, there is a strong link between brain development and the behaviour of individuals.

Behaviour exhibited by adolescents is closely related to their stage of brain development (Hazen, Schlozman & Beresin, 2008). Research using structural brain imaging has shown that brain development continues into the early twenties. The patterns of growth of white matter occur in such a way that the sensory and motor regions mature first, followed by the maturation of the prefrontal areas linked to executive functions (Hazen et al., 2008; Pfeifer et al., 2011). Initially, there is incomplete myelination that causes emotionally "hot" settings to trigger heightened limbic brain activity while the executive brain regions do not have equal impact, resulting in an unreasonable over-reaction to a situation. Table 2.1 shows a progression of behaviour linked to the maturation of the frontal lobe. Puberty affects arousal and motivation, especially before the frontal lobes have matured fully, which may lead to young adolescents' increased difficulty in controlling their emotions and behaviour. This may assist in providing reasons for adolescents' increased risk-taking and exhibiting affective and behavioural problems (Steinberg, 2005).

Table 2.1: Progression of adolescent behaviour related to the maturation of the frontal lobe (adapted from Steinberg, 2005)

EARLY ADOLESCENCE	MIDDLE ADOLESCENCE	LATE ADOLESCENCE
Puberty heightens emotional arousability, sensation seeking and reward orientation.	Period of heightened vulnerability to risk-taking and problems in the regulation of affect and behaviour	Maturation of frontal lobes facilitates regulatory competence

Casey, Duhoux and Malter Cohen (2010) note that fundamental motivational and emotional systems are activated at a stage when prefrontal cortical systems concerned with rational decisions and actions are not fully mature. This contributes to the regression behaviours exhibited by adolescents when experiencing stress. This sometimes manifests in the form of rigid approaches to problem solving (Hazen et al., 2008).

2.3.2 Adolescence

Adolescence is the transitional period from dependence in childhood, ending with independence from the parent (Casey et al., 2010). It is marked by rapid physiological growth as well as psychological and emotional changes (Papalia & Olds, 1981). Puberty, on the other hand, refers to the processes involved in reproductive maturation (Casey et al., 2010).

The exact onset and end of adolescence are difficult to determine as various biological, psychological and social factors are at play (Hazen et al., 2008). However, for boys, it begins approximately at the age of 12 and concludes at 18-21 years of age (Papalia & Olds, 1981). With the onset of puberty, an adolescent experiences increased sensitivity to socio-emotional situations (Pfeifer et al., 2011) and motivational and interpersonal influences (Casey et al. 2010).

Hormonal secretions during adolescence have an influence on school performance. Martin and Steinbeck (2017) found a link between puberty hormones and lower achievement. These hormones predicted pubertal status, which was associated with lower self-efficacy. They found lower self-efficacy to be associated with lower achievement. While hormones did not significantly predict achievement, these researchers established that motivation is a significant driving force behind these results. Hormones also alter the secretion of melatonin. The adolescent then naturally experiences a delay in the onset of the sleep phase and wakes up later. Simultaneously, there are increases in academic and social demands, depriving him/her of the sleep the body naturally needs. Fatigue and too little sleep are common amongst adolescents and can lead to poor concentration and underperformance in the classroom (Hazen et al., 2008).

Theurel and Gentaz (2018) explain that the physical changes that occur during adolescence, and the timing thereof, affect the emotional and social functioning of the adolescent. When the onset of puberty deviates from the mean, the adolescent can be affected (either positively or negatively). Males who develop early are inclined to have increased self-confidence and a higher likelihood of academic success than their peers, especially when compared to late-developing males (Hazen et al., 2008). Adolescents typically experience accelerated growth that outpaces the increase in muscle mass, causing the adolescent male, especially, to experience a measure of awkwardness. This could contribute to poor self-concept, negatively affecting school performance. Therefore, teachers should be sensitive to the ways in which these physical changes may affect the adolescent (Hazen et al., 2008).

Erikson (cited in Papalia & Olds, 1981) views adolescence as a peak time for establishing identity. Noam (cited in Hazen et al., 2008) challenges this notion with his theory "the psychology of belonging" in which he argues that young adolescents are more concerned with the development of group cohesion than forming an identity. Pfeifer and Peake (2012), on the other hand, consider the establishment of identity and the need for being part of a group as interrelated. As children mature into adolescents, a shift occurs in their self-assessment as they become more aware of how they compare to others. Typical adolescent behaviours such as being self-conscious are necessary for this understanding of "who am I really?" to develop and to reason about others' opinions of the self (Pfeifer, Masten, Borofsky, Dapretto, Fuligni & Lieberman, 2009).

Forming an accurate sense of self is a cognitive and social construction. An individual's cognitive abilities, along with social inputs from peers and family, contribute to an adolescent forming a view of him-/herself. A sense of belonging or relatedness is derived, in part, from an increased grasp of one's own abilities and preferences and how these relate to those of others (Pfeifer & Peake, 2012). Therefore, the need for relatedness and connection with peers is especially high in early adolescence. Eccles (1999) insists that young adolescents, in particular, have this desire to connect with their peers, but that they also need to have positive input from non-familial adults such as teachers. However, while older adolescents have an affinity for their peers, they are less influenced by them and have a stronger drive to form their own identity (Pfeifer et al., 2011).

2.4 TRANSITION TO HIGH SCHOOL

The transition to high school is a stage in a learner's schooling characterised by several simultaneously occurring events. Learners usually experience a decrease in self-perceptions, such as self-concept and self-efficacy when transitioning to high school (Eccles, 1999; Eccles & Roeser, 2011). This regularly translates into poorer academic performance (Arens, Yeung, Craven, Watermann & Hasselhorn, 2013). Most learners transitioning to high school are also experiencing the onset of puberty, which is considered by Barber and Olsen (2004) to be an influencing factor behind these declines. Another contributing factor is that peer pressure peaks in Grade 8 or 9 at a time when parental involvement decreases (Schunk & Pajares, 2002).

Coelho and Romão (2017) conducted a study with Portuguese learners and assessed their change in self-efficacy and self-concept from Grade 4 (final year of primary school) to 5, their first year of high school. They found that there was a decline in both aspects during the first year of high school. Arens et al. (2013) conducted research with German learners who transition to high school at the end of Grade 4, prior to puberty. These researchers investigated whether it was the actual transition that caused a decline in these self-perceptions and academic performance, or whether it was the start of adolescence that was the cause. They concluded that the decrease in self-perceptions of these learners was mainly ascribed to the transition rather than puberty, and the simultaneous occurrence of the transition.

Barber and Olsen (2004) examined the perceived quality of the school milieu and reduced academic/personal/interpersonal performance for five consecutive grade transitions (Grades 5 to 10). Even though a transition did not occur between every grade, learners reported a deterioration in the quality of the school milieu and a decline in academic/personal/ interpersonal performance at every grade transition. This was most prominent from Grade 6 to 7, where there was no transition to a new school, but rather a change in these categories of functioning when transitioning from the more nurturing environment of small family pods to a more typical high school environment the following year. Wigfield, Eccles, MacIver and Reuman (1991) found that changes in the school environment on entry to Grade 7 caused learners' self-concepts regarding their mathematical ability to decline. This highlights the effect of environment (perceived or real) on academic functioning.

2.5 PSYCHOLOGICAL AND AFFECTIVE CONCEPTS

In order to examine learners' achievements and contributing factors holistically, psychological and affective factors need to be taken into account. Therefore, concepts, such as self-efficacy, self-concept, self-regulation and motivation are presented here.

2.5.1 Self-Efficacy

Bandura (2009) defines self-efficacy as the individual's belief in his/her ability to organise and execute a given course of action to solve a problem or accomplish a task. It differs from other concepts of self in that it is a perception of self-competence related to a *particular* task (Gaskill & Hoy, 2002) and is the self-confidence exhibited in a specific situation (Bandura, cited in Rodgers, Markland, Selzler, Murray & Wilson, 2014).

Self-efficacy is a crucial construct in Social Cognitive Theory (Rodgers et al., 2014) which suggests that performance is reliant on interactions between one's behaviours, environmental conditions and personal factors, such as thoughts and beliefs (Bandura, 1977). This multidimensional construct varies in strength, generality and difficulty. Thus, some people have a strong sense of self-efficacy while others do not; some have efficacy beliefs that encompass many situations whereas others have narrow efficacy beliefs; and some believe they are efficacious even on the most difficult tasks whereas others believe they are efficacious only on easier tasks (Pajares, 1996).

As in the expectancy-value and attribution theories, Bandura's self-efficacy theory focuses on the significance of expectancies for success:

> Human behavior is extensively motivated and regulated through the exercise of self-influence. Among the mechanisms of self-influence, none is more focal or pervading than belief in one's personal efficacy. Unless people believe that they can produce desired

> effects and forestall undesired ones by their actions, they have little incentive to act or to persevere in the face of difficulties. Whatever other factors may serve as guides and motivators, they are rooted in the core belief that one has the power to produce desired results. That belief in one's capabilities is a vital personal resource (Bandura, 2009:179).

Eccles and Wigfield (2002) postulate that Bandura distinguishes between two types of expectancy beliefs: outcome expectations and efficacy expectations. The former refers to beliefs that particular actions will lead to particular outcomes (e.g. "Doing my homework will improve my understanding."). The latter is concerned with whether one can successfully perform behaviours required to produce the outcome (e.g. "I can study hard to achieve good marks."). These two types of expectancy beliefs are different because individuals can believe that a certain behaviour will produce a certain outcome (outcome expectation), but may not believe they can perform that behaviour (efficacy expectation). Bandura proposed that individuals' efficacy expectations are the major determinant of personal goal setting, activity choice, willingness to expend effort, and persistence (Eccles & Wigfield, 2002). In other words, the higher the self-efficacy, the greater the commitment to one's goals (Bandura, 1993; 2009).

Several studies have investigated the influence of self-efficacy on academic achievement and, although their findings are not consistent, the strong link between self-efficacy and achievement is evident (Hannula, Bofah, Tuohilampi & Metsämuuronen, 2014). Liu and Koirala (2009) conducted a study involving Grade 10 (sophomore) learners to assess the significance of the relationship between self-efficacy and mathematics achievement, as well as the measure of predictability of mathematics achievement, using self-efficacy in mathematics. Their results showed that there is a positive correlation between self-efficacy in mathematics and mathematics performance. This relationship was particularly true for learners who were confident in mathematics. According to Causapin (2012), self-efficacy is a positive predictor of achievement, but only for male individuals who are higher mathematics performers. This differs from the findings of Multon, Brown and Lent (1991) who suggest that self-efficacy has a greater effect on the achievement of low-performing learners. These researchers also found that older students make more accurate efficacy judgements. Davis-Kean, Huesmann, Jager, Collins, Bates and Lansford (2008), who examined the relationship between self-efficacy beliefs and behaviours across time in a sample of learners from Grade 1-12 and found that the relationship between self-belief and behaviour increases with age, confirm this effect of age on self-efficacy.

In a study examining Grade 8 learners' motivation, attitude and academic engagement, Singh, Granville and Dika (2002) showed that attitude and self-efficacy contribute significantly to mathematics performance. According to these researchers, these attitudes and low-motivation behaviours may have their roots in elementary school experiences. Ma and Kishor (1997) and Ma and Xu (2004) included attitude to mathematics and its relation to mathematics achievement in their studies, finding that self-efficacy, rather than attitude, was a more powerful predictor of mathematics achievement. Since self-efficacy affects tenacity, determination, resilience and, ultimately, achievement, those with a higher level of self-efficacy for learning generally put in more effort and are more persistent when encountering academic challenges than learners who mistrust their academic capabilities (Eccles & Wigfield, 2002; Bandura, 2009). As a result, the former achieve at a higher level (Schunk & Pajares, 2002).

The impact of self-efficacy on mathematics achievement is not always one directional. In a longitudinal study with 3 502 Finnish students from the beginning of Grade 3 to the end of Grade 9, Hannula et al. (2014) investigated the direction of causality between self-efficacy and achievement and determined that mathematics achievement and self-efficacy have a reciprocal interaction with the dominant effect being from achievement to self-efficacy. In two longitudinal studies, Skaalvik and Skaalvik (2011) found that self-concept and self-efficacy were important mediators of academic achievement and that students' self-efficacy strongly predicted achievement, even more so than prior achievement, confirming the view of Pajares and Miller (1994). Schunk (1990) explains that in Pintrich and De Groot's study of seventh graders, self-efficacy related positively to the use of cognitive and self-regulatory approaches as well as to learners' marks achieved, suggesting that self-efficacy could indirectly affect performance through its effect on strategy use.

Hannula, Maijala and Pehkonen (cited in Hannula et al., 2014) propose that there is a developmental trend in the relationship between self-efficacy and achievement, starting with a relationship dominated by achievement, which becomes a reciprocal relationship towards the end of primary school, eventually evolving into a self-efficacy-dominated relationship in high school learners. Capara, Vecchione, Alessandri, Gerbino and Barbaranelli (2011) observe that the effect of self-efficacy at age 13 on achievement at age 16 was equivalent to the effect of achievement at age 13 on self-efficacy at age 16. In a longitudinal study on changes in learners' accuracy in terms of rating their self-efficacy in Grades 5, 8 and 11, Zimmerman and Martinez-Pons (1990) found that their accuracy in doing so increased from Grade 5 to 8, and from Grade 8 to 11. However, the greatest improvement was from Grade 5 to 8, coinciding with the onset of puberty and the transition to high school. In addition, Schunk and Pajares (2002) report that self-efficacy beliefs weaken, partly due to the more accurate assessment of self, as a learner progresses through school and that this is more evident in weaker learners who have to cope with increasingly difficult academic challenges.

2.5.2 Self-Concept

Self-concept is a complex, multi-faceted belief, which involves individuals' overall view of themselves and their attributes, as well as how they perceive others' opinions of them (Meggert, cited in Parker, 2010). This global construct is formed by comparing oneself to others and is heavily influenced by feedback and assessments by significant others (Shavelson & Bolus, 1982).

2.5.2.1 The interaction between self-concept and self-efficacy

There are similarities and differences between self-efficacy and self-concept. Self-efficacy and self-concept both predict motivation and performance to various degrees and use the extent of mastery and reflection on performance as information sources for future behaviour. However, self-efficacy is related to judgements about capabilities, where the focus is mainly on an individual's assessment of his/her personal competency to complete a specific task with no external or internal comparisons made to self (Gaskill & Hoy, 2002). On the other hand, self-concept is concerned with routine evaluation of skills and abilities, often in comparison to others (Bong & Skaalvik, 2003). As self-concept develops, these social comparisons may affect self-worth which, in turn, influences the self-efficacy level in an individual (Schunk &

Pajares, 2002) and, therefore, self-concept is useful in predicting how a learner behaves (Bong & Skaalvik, 2003).

Seaton, Parker, Marsh, Craven and Yeung (2014) provide evidence that the effects between self-efficacy and achievement are similar in terms of extent. However, some researchers found that mathematics self-efficacy is better than mathematics self-concept or previous experience when it comes to predicting mathematics achievement (Pajares & Miller, 1994). Self-efficacy has been shown to have as much of an effect on performance as mental ability (Pajares & Kranzler, 1995) as it affects learners' goals (Zimmerman & Bandura, 1994) and motivates them to improve (Schunk, 1995).

2.5.2.2 Academic self-concept

Learners also have subject-specific self-concepts which, according to Schunk and Pajares (2002), work together to construct an individual's general academic self-concept. Primary school learners often overrate their ability to critically assess their competence and yet learners often have a reduced self-concept in the transition to middle school. (In this context, middle school begins in Grade 6.) As learners reach Grade 7 (the beginning of the Senior Phase in the SA education system), they are more able to accurately evaluate their academic abilities and how others view their skills, allowing their academic self-concept to be more accurate (Manning, 2007).

Learners' perception of self becomes more complex as they mature, and their self-concept is influenced by their own experiences and significant others, such as teachers, parents and peers (Shavelson & Bolus, 1982). According to Parker (2010), the rapid growth and changes in early adolescents can cause their self-concept to be more vulnerable than before. Domain-specific self-concepts such as intelligence, and academic self-concepts in adolescents, in particular, are more open to positive and negative effects as young adolescents evaluate themselves more accurately and make intense social comparisons (Wigfield et al., 1991).

Studies have shown that there is a significant positive correlation between high school students' self-concept and their motivation to achieve (Khan & Alam, 2015). However, Baumeister, Campbell, Krueger and Vohs (2003) argue that self-concept is a consequence of high achievement rather than a causal factor, suggesting that increasing a learner's academic skills is of more value when it comes to bolstering self-concept than vice versa.

2.5.3 Self-Regulation

The field of self-regulated learning not only includes learning styles and metacognitive awareness and skills, but as Boekaerts and Niemivirta (2000) suggest, it is also about having an understanding as to why learners are willing to do what they do and why, at times, they do not do what is required of them.

Self-regulated learning requires learners to set up and remain committed to their own goals while safeguarding these from conflicting alternatives. Boekaerts (1999) also notes that self-regulated learning is a chain of reciprocally-interrelated cognitive and affective processes aimed at working on various aspects of the information processing system, where learners are involved in self-monitoring, reflecting and setting goals (Gaskill & Hoy, 2002). Bouffard-Bouchard (1990) asserts that self-efficacy is an important construct, especially regarding academic activities requiring prolonged self-regulation. These goals allow for sustained motivation, giving direction and invigorating behaviour, allowing self-regulating learners to manage the interplay between what they know, the resources at their disposal and the deviations that may be necessary in order to accomplish their goals (Lemos, cited in Boekaerts, 1999). Through this interactive process, learners continually make adjustments in order to maximise their chances of succeeding (Winne, 1995).

Zimmerman and Martinez-Pons (1990) report that in their longitudinal study of self-regulated learning, Grade 11 learners surpassed Grade 8 learners, who surpassed Grade 5 learners in self-regulated learning. This suggests that self-regulation in learners improves with age. According to Zimmerman (1989), self-regulated learners apply definite strategies to reach academic goals in accordance with self-efficacy perceptions. As shown, the three perceptions, i.e. self-efficacy, self-concept and self-regulation, all contribute to a learner's level of motivation. In the following section, these perceptions, along with their role in influencing motivation, are unpacked.

2.5.4 Motivation

Motivation is the driving force behind an individual's action. It is concerned with intent, energy and direction of focus (Ryan & Deci, 2000b). Customarily, motivation is divided into two categories, namely intrinsic and extrinsic motivation. Intrinsic motivation is characterised by personal satisfaction, curiosity, or pleasure whereas extrinsic motivation is controlled by reinforcement contingencies (Guthrie, Wigfield & Vonsecker, 2000; Lai, 2011). Ryan and Deci (2000a) developed their Self-Determination Theory (SDT) in order to explain the operational and experiential differences between intrinsic and extrinsic motivation. This theory provides a distinction between several types of motivation by determining the underlying principles governing each type, and how it manifests (SDT is discussed in detail in Chapter 3).

Several researchers have investigated the relationship between motivation and school achievement. Lange and Adler (cited in Liu & Koirala, 2009) report that motivation is a stronger predictor of achievement than intelligence. By contrast, Seaton et al. (2014) claim that the influence of achievement on motivation is greater than the effect of motivation on achievement. Fraser, Walberg, Welch and Hattie (cited in Singh et al., 2002) report that apart from previous achievement, motivational variables have one of the greatest effects on performance in Grade 8. According to Eccles and Wigfield (2002), learners perform better and are more motivated to choose more difficult tasks when they believe that they can do the task. They also state that if learners believe that they can do a task (are highly efficacious), it does not mean that they will go over to action as they might not see the worth of doing it and therefore not engage in the activity.

2.5.4.1 Academic motivation

Academic motivation is the love for school learning that is epitomised by enquiry, perseverance and mastery of challenging concepts (Gottfried, 1990). However, many mathematics-related activities are not necessarily interesting to learners. Yet if they are to achieve in the subject, they need to be motivated or motivate themselves to engage and respond to the task at hand (Ryan & Deci, 2000a). This is why finding the motivation from within the self is critical if the level of performance is to increase, because academic motivation is strongly related to and essential for academic performance (Gottfried, Fleming & Gottfried, 2001; Pintrich, 2003).

When learners are motivated by punishment or reward, they are inclined to take shortcuts, causing their academic performance to deteriorate and, subsequently, their self-efficacy to decrease (Hannula et al., 2014). These learners then persevere less and put in less effort (Hannula et al., 2016). If learners are struggling academically, they may engage in negative learning behaviours, such as procrastination, avoiding seemingly difficult activities and making excuses (Covington & Omelich, cited in Eccles & Wigfield, 2002). This is to avoid being viewed as having low ability when, in fact, they lack the confidence (Dweck, 2002) and self-efficacy to perform the task.

On the other hand, learners will be more motivated to participate in an activity if they can excel at it (Liu & Koirala, 2009). Such learners will also have more positive perceptions of their academic competence and have lower academic anxiety. Academic motivation develops cumulatively because not only does the previous stage predict the next, but it affects motivation throughout schooling with various indirect effects (Gottfried et al., 2001). Learners who perceive themselves as having more academic competence will achieve higher marks due to increased autonomous academic motivation (Guay, Ratelle, Roy & Litalien, 2010).

2.6 MATHEMATICS PERFORMANCE

Mathematics performance is an umbrella term for a range of components each of which consists of a variety of skills and abilities demonstrated when performing a mathematics-related activity. These skills and abilities influencing mathematics performance are multifaceted and interactive. Consequently, these competencies, together with prior knowledge, affect the grasp of new concepts. This makes it more difficult to determine factors that specifically influence mathematics performance. Tosto et al., (2017) demonstrate this by using the concept of ‘number sense’, which describes a broad spectrum of mathematically-relevant concepts comprising as many as 30 different constructs. Estimation is one such heterogeneous construct that depends on non-symbolic and symbolic estimation subskills, as well as on quantifying and symbolising number magnitudes. While these subskills are all mathematics skills, the degree to which each has an impact will depend on the specific task and stage of development of the individual (Tosto et al., 2017). To complicate matters further, some researchers (Rittle-Johnson & Alibali, 1999) distinguish between three areas of mathematical knowledge, namely procedural knowledge, conceptual knowledge and *gains* in this knowledge. Procedural knowledge is defined as the *how to* or "action sequences" for solving mathematical problems while conceptual knowledge is the *why* behind the procedure (Rittle-Johnson & Alibali, 1999). Rittle-Johnson and Alibali (1999) also suggest that conceptual knowledge has a larger influence on procedural knowledge than vice versa. Gains in mathematical knowledge refers to the increase in this knowledge from an earlier to a later age (Watts, Duncan & Siegler, 2014). Thus, the discussion on the interwoven connectedness of skills affecting mathematics performance should be viewed through this lens.

2.6.1 General

Longitudinal, quantitative research into the mathematics performance of learners is sorely lacking in South Africa. However, panel data sets, which comprise multiple observations of learners in a sample over an extended period, reveal that performance in earlier years predicts subsequent performance (Reddy, Prinsloo et al, 2012). It would be ideal if longitudinal data on learners' cognitive, social and emotional skills were obtained prior to schooling and during each grade until they matriculate. This would allow for disaggregation of influencing aspects of the learners' lives and meaningfully attribute weightings to various effects on mathematics performance (Spaull & Kotze, 2015).

Spaull and Kotze (2015) warn that early intervention to correct and avoid learning deficits as learners progress through school is critical to improve average achievement in schools. Numerous aspects of mathematical understanding longitudinally predict and cause overall mathematics performance. These include knowledge of number magnitude, whole numbers and rational numbers (Siegler, 2016). In a review of the results of six longitudinal studies in the USA, Canada and Great Britain, Duncan et al., (2007) found that after controlling for IQ, reading level and attention, comprehension of numbers and ordinality were the greatest predictors of future learning.

The importance of earlier understanding of numeracy and its effect on later learning of more intricate calculations, using larger numbers as well as problem solving, is confirmed by Jordan et al. (2009), Jansen (2012) and Reddy, Van der Berg, Van Rensburg and Taylor (2012). Claessens, Duncan and Engel (2009) and Duncan et al. (2007) assert that the correlation between earlier and later performance is relatively stable. Watts et al. (2014) disagree, maintaining that individual variations in mathematics performance increase longitudinally and that several factors could potentially alter learners' longitudinal performance trajectories, resulting in declining correlations. They cite changes in motivation and classroom instruction as well as whether key skills are mastered as contributors to changes in mathematics performance.

2.6.2 Foundation Phase (Grade 1 in Particular)

When a child enters Grade 1, he/she already has a 'history' of mathematics learning. This prior knowledge, in part, determines the effectiveness of his/her springboard into future mathematics learning. Learners who have poor prior knowledge will be at a disadvantage compared to their peers, who have a greater sense of numbers (Fritz et al., 2013).

Schollar (cited in Spaull & Kotze, 2015) reasons that the hierarchical nature of mathematics demands that conceptual frameworks are mastered in a progressive and accumulative fashion to allow for more complex cognitive skills to develop. He asserts that it is crucial for learners to have an intuitive grasp of place value within the base-10 number system, and that they are able to identify relationships between numbers and perform basic calculations, using the four operations with ease. To promote increased performance later in their schooling, learners must progress from counting to "true calculating" while still in primary school. Progressing weaker learners before these basic skills have been mastered results in their not fully engaging in the grade-appropriate curriculum. According to Spaull and Kotze (2015), the reason that South African learners find the TIMSS test more difficult is that they are falling behind in the curriculum and finding it difficult to build on earlier concepts. The following section highlights more challenging concepts in school mathematics.

2.6.3 Challenging Mathematical Concepts

In this section, three selected concepts, which are considered challenging to many mathematics learners are briefly highlighted. Each of the concepts are elucidated by underscoring the important foundation skills needed for easier mastery of the concept later in school. This also includes the progression of the chosen concepts at school, while drawing attention to potential difficulties. The selected areas are the multi-step procedure long division, fractions and algebra. These were chosen based on the researcher's personal experience and literature, where there is evidence that these seem to pose particular challenges for learners. Moreover, the first two concepts, namely long division and fraction knowledge, are considered predictors of performance in algebra and subsequent mathematics achievement (Siegler et al., 2012). The CAPS curriculum (Department of Basic Education, 2011) was used as a guideline in the following discussion pertaining to these concepts taught in various grades.

2.6.3.1 Long division as an example of a multi-step procedure

Multi-step procedures in mathematics are challenging for a number of learners. Furthermore, division is considered the most challenging of arithmetic operations, with long division being particularly difficult (Camos & Baumer, 2015). There are several factors that make long division challenging. One of these is that even the simplest division requires at least two steps: estimation occurs, followed by a quotient and a remainder being determined. For example, to solve $\frac{9}{2}$: the learner would have to divide ($8 \div 2 = 4$) and afterwards subtract ($9 - 8 = 1$), resulting in more than one retrieval from long-term memory (Camos & Baumer, 2015).

In Grade 6, the most complex long division is introduced, where four-digit numbers and three-digit whole number dividends are used. In the years prior to this, learners are taught separate skills, such as what the four operations mean; estimation; rapid recall, using the four operations (+, −, X, ÷) (Grade 3); accuracy with times tables; a simpler version of long division; and using multiplication and division as inverse operations (Grades 4 and 5). Several skills (including those mentioned) need to be mastered for the intricate long division in Grade 6 to be executed accurately. Multiplicative knowledge is essential for efficient division, but is even more critical for long division, where several retrievals of facts are done in succession (Robinson, 2006). The cognitive demands on learners to integrate these skills in this complex multi-step calculation are immense and Camos and Baumer (2015) found that the more computational steps a long division sum demands, the greater the extent of information to keep track of and the weaker the performance of learners. Another complication is the manner in which long division is presented on paper. Trbovich and LeFevre (2003) state that when calculations are presented vertically, they require more visual resources than when presented horizontally. Learners who have visuospatial constraints may be affected to a greater extent. This vertical presentation, together with the number of steps involved, increase the cognitive demands on the learner. As cognitive load increases, the learner has reduced attention available for solving intermediate calculations, causing errors in the long division (Camos & Baumer, 2015).

As has been shown, multi-step procedures, where several skills are applied simultaneously, while the learner has to keep track of what has or still has to be done, make calculations such as long division taxing. In addition to requiring a good grasp of the necessary elementary components, a high level of attention capacity is also essential for accurate implementation of each step.

This discussion has illustrated the importance of a solid foundation of basic skills early in primary school. If the basics are in place, the learner's prospect of mastering multi-step procedures such as long division is improved. Subsequently, mastering long division will have a positive effect on mathematics performance in high school when, for example, algebra is introduced.

2.6.3.2 Fractions

Fractions is a section of the curriculum with which many learners experience difficulty (Vukovic, Fuchs, Geary, Jordan, Gersten & Siegler, 2014). The preparation for mastering fractions occurs in the Foundation Phase, and even earlier. Whole-number knowledge in Grade 1 was found by Bailey, Siegler and Geary (cited in Watts et al., 2014) to be a predictor of fraction conceptual knowledge as well as fraction arithmetic ability in Grades 7 and 8. Hansen et al. (2015) ascertained that fraction concepts were uniquely influenced by locating whole numbers on a number line. Both whole number knowledge and number line work are key concepts taught in the Foundation Phase.

Other important concepts that form the basis for fraction mastery involve the rapid recall of facts involving fractions, including times tables (Grade 3 and onwards), understanding the four operations (Grade 3), as well as the commutative, associative and distributive properties of numbers (especially Grades 4 to 6 and onwards). Being able to calculate fluently in all operations is required by Grade 6 (Department of Basic Education, 2011). Oakley, Lawrence, Burt, Boxley and Kobus (2003) assert that learners, who practise mathematical facts to an automatic level, achieve a deeper understanding of mathematics. Vukovic et al. (2014) found that competency with number line work, together with multiplication and division fact fluency, also affected fraction procedures, underlining the complexity of the pathway to successful fraction manipulation, which explains why this section of mathematics is challenging.

2.6.3.3 Abstract nature of algebra

The primary school curriculum focuses on several concrete concepts and many topics are meant to be taught in a concrete manner, using visual aids and practical examples from everyday life. Examples in the Foundation Phase include the use of a visual aid for a number line and drawing a story sum, the latter being a precursor to number sentences and algebraic expressions. The magnitude of numbers (Grades 1-3) and concepts such as exponents (Grade 7) also provide a foundation for mastering algebra in high school. DeWolf, Bassok and Holyoak (2015) consider early success with algebraic expressions to be closely linked to a learner's understanding of fractions and decimals.

When algebra is introduced in grade 8, learners grapple with the notion that a 'letter' (known as a variable) can also represent a number, a range of numbers, or a fraction. They then learn that the operations applied to numbers can also be used with two or more 'letters' (a x b = ab), and that there are several new laws that come into play. This can pose a significant challenge to learners who have relied on a more concrete approach or who have not come to grips with, for example, the operations used in primary school. Pournara et al. (2016) found that learners, especially in the first years of exposure to algebra, struggle with concepts, such as the use of negatives and brackets, the application of the law governing addition of exponents and the use of the distributive law.

While only three areas were highlighted in the above discussion, it is clear that the components allowing mastery of any one mathematical concept are interwoven and reliant on one another for accurate execution and processing of the procedures related to the said concept.

2.6.4 Gains in Mathematics

Gains in mathematics refers to the growth in mathematical knowledge over time. Watts et al. (2014) conducted a study that not only assessed initial mathematical knowledge at 54 months of age, but also established *gains* in this mathematical knowledge to the end of Grade 1. They found that when controlling for pre-school cognitive ability and other academic skills, the *growth* in that knowledge was a greater predictor of mathematics achievement at age 15 than the initial knowledge. This might be indicative of learners' response to school instruction and, therefore, a sounder indicator of achievement in high school. This *gain* in mathematical knowledge from the end of pre-school to the end of Grade 1 was also found to be an equally strong predictor of mathematics achievement in Grade 3, where the curriculum more closely resembles the counting and arithmetic skills initially assessed as it was of achievement at age 15, where skill in solving algebraic equations and using geometry theorems is required (Watts et al., 2014). This finding highlights that learners who master skills early benefit more from future instruction in mathematics because grasping mathematical concepts that are more complex depends on the level of proficiency in earlier concepts.

The findings of Jordan, Kaplan, Locuniak and Ramineni (2007) were similar to those of Watts et al. (2014) in that the rate of growth in early number competence predicted mathematics achievement between Grades 1 and 3. However, the former (Jordan et al., 2007) differed in that they found that early number competence strongly related to mathematics achievement, stressing the significant role increased number competence plays in determining learners' trajectories in primary school mathematics. Duncan et al. (2007) reported a consistent and very strong relationship between gains in early mathematical skills and mathematics performance in high school, suggesting that learners who master more skills earlier on have a stronger foundation on which to build future skills, resulting in a stable mathematics performance trajectory through high school. They consider this particularly beneficial in a subject such as Mathematics where mastering new concepts is reliant on earlier skills gained.

2.6.5 South African and International Research

Longitudinal studies of mathematics performance spanning more than three or four years are rare (Pournara et al., 2015). These extended studies have their own unique challenges, such as the availability of the subject for testing at intervals over time or the accessibility of the same type of data (e.g. task performance results) from the specific individual. However, the longitudinal mathematics performance studies that have been conducted reveal some interesting findings.

A South African study by Reddy, Van der Berg et al. (2012), using TIMSS 2002 Grade 8 data and Grade 12 promotion marks, revealed a high correlation between mathematics performance in Grades 8 and 12, emphasising the need to improve achievement by Grade 8 in order to augment Grade 12 results. Spaull and Kotze (2015) and Reddy et al. (2016) propose that it is virtually impossible for learners, who have accumulated gaps in their early primary school mathematical knowledge, to 'catch-up' sufficiently to achieve their best in

Grade 12. Reddy, Van der Berg et al. (2012) suggest that in order to improve mathematics performance in Grade 12, scores prior to high school must be improved as once a learner has entered high school in Grade 8, it is too late to make any substantial improvements to matric performance. This, they partially attribute to the pace, progression and sequence of mathematics in high school, making mastering more advanced concepts and procedures very challenging.

Reddy, Van der Berg et al. (2012) also found that South African learners who had high Grade 8 Mathematics scores were able to pass Grade 12 regardless of socio-economic status. Jansen (2012), who maintains that it is very difficult to fail Grade 12 in South Africa, challenges the significance of this finding although the point Reddy, Van der Berg et al. (2012) are making stresses the *strong correlation* between Grades 8 and 12.

More recently, TIMSS 2015 results confirmed the dismal state of South African mathematics performance. In TIMSS 2015, schools were sampled as follows: Quintiles 1-3 comprised 65% of schools, Quintiles 4 and 5, 31% while independent schools made up 4%. Table 2.2 below provides a summary of these findings.

Table 2.2: Comparison of types of South African schools comprising the TIMSS 2015

Type of school	Quintiles 1-3	Quintiles 4 & 5	Independent
Proportion of sample schools	65%	31%	4%
Fees	Public non-paying	Public fee-paying	Fee-paying
TIMSS Average scale score (SE)	341 (3.3)	423 (10.0)	477 (11.5)

SE=Standard Error

The Average Scale Score achieved nationally in 2015 was 372, where South Africa's Grade 9 learners ranked second last to Saudi Arabia, who used Grade 8 learners in their sample. The centre point score, which is the average international score, is 500. Therefore, South Africa, including the upper quintile schools, achieved well below the international average. While there has been an improvement in South Africa's Average Scale Score since 2003, on closer inspection, the question arises: Is this improvement as good as it appears? In 2003, when

Grades 8 and 9 learners formed part of the sample, the score was 264. In 2011 and 2015, when only Grade 9 learners were assessed, it was 352 and 372 respectively. It is likely that the increase in scores from 2003 to 2011 was due to the change in the composition of the sample, which excluded Grade 8 learners. As seen in Table 2 and the discussion here and in Section 1.3.2, all quintile schools are not competitive internationally.

2.7 EARLIER ACHIEVEMENT PREDICTING LATER ACHIEVEMENT

Research examining predictors of achievement in subsequent grades based on earlier achievement can be divided into two main categories. The first, into which the present study falls, does not consider specific learner competencies, but rather only determines the extent to which learners' current grade average mark predicts their average mark in a later grade. The study conducted by Reddy, Van der Berg et al. (2012), discussed in Section 2.6.5, is also an example of this. A broad comparison such as this allows trends to be determined and attention to be drawn to the strength of some of the links between grades.

The second category includes studies where specific subskills are the focus and researchers have identified various mathematical concepts and skills taught early on in school as playing a crucial role in subsequent mathematics performance (Fleisch, 2008; Spaull, 2013b; Taylor et al., cited in Spaull & Kotze, 2015). Geary, Hoard, Nugent and Bailey (2013) claim that the correlation between knowledge of numbers in the first couple of grades and mathematics achievement in high school is particularly strong. Claessens et al. (2009) found that the most effective means of improving Grade 5 achievement is to boost the basic academic abilities of underachievers before they enter Grade 1 because the level of understanding of the number system in pre-school is a strong indicator of mathematics performance in middle school (Intermediate and Senior Phases). The research done by Geary (2011) endorses this in that early quantitative competencies in Grade 1, such as advanced counting methods for solving addition problems, ease in manipulating numbers and accurate placement of whole numbers on a number line, specifically, were shown to contribute to mathematical learning in Grade 5.

Jordan et al. (2009) and LeFevre et al. (2010) found that early number competence was an important predictor for determining children's mathematical learning trajectories in primary school. Hannula-Sormunen, Lehtinen and Räsänen (2015) confirm this and recommend early practice in order to permanently change basic number concept, which they found to subsequently heighten abstract concept of number. In Grade 1, skills in representing numerical magnitude are correlated to learning arithmetic and predict Grade 1 learners' ability to solve unfamiliar arithmetic problems in the future (Booth & Siegler, 2008). These studies all show the importance of early learning which plays a crucial role in setting a child's learning trajectory for the future.

In a study by Bailey, Hoard, Nugent and Geary (2012), assessing the co-developmental relationship between knowledge of fractions and mathematics achievement, it was established that fractions procedural ability in Grade 6 predicts mathematics achievement in Grade 7. They also found that knowledge of fractions in Grade 6 predicts gains in subsequent mathematics achievement.

Both categories have advantages. The first allows for grades to be identified that have high correlations with others and where more specific research is needed while the second highlights the importance of mastering a specific subskill before progressing to the next concept or grade. Specifics, such as weaknesses in learners' reasoning and procedural thinking can be exposed, allowing the root of the problem to be addressed rather than merely advocating that a topic be retaught (Pournara et al., 2016).

2.8 CONCLUSION

In the literature, it is evident that mathematics achievement, various self-perceptions and types of motivation significantly influence one another and that the developmental stage of an individual plays a crucial role in the effectiveness of an appropriate response in the classroom by that learner. With this in mind, the Self-Determination Theory of Ryan and Deci (2016) and Piaget's Cognitive Theory provide the focus for the theoretical framework to follow.

CHAPTER 3

THEORETICAL FRAMEWORK

3.1 INTRODUCTION

The theoretical framework for this study draws on two macro-theories, both of which support an organismic meta-theory. The first is Ryan and Deci's Self-Determination Theory (SDT) and the second Piaget's Cognitive Theory.

3.2 SELF-DETERMINATION THEORY

A primary focus of the Self-Determination Theory (SDT) is to offer a differentiated approach to motivation by describing the possible types thereof (Ryan & Deci, 2016). These researchers define self-determination as the degree to which behaviour stems from within an individual (Guay, Chanal, Ratelle, Marsh, Lorose & Boivin., 2010). In other words, the more a behaviour originates within the self, the more self-determined an individual is regarding that behaviour. This view of human motivation underscores the value of the inner resources developed by humans for personal growth and self-regulation (McCulloch, 2009).

In order to offer an explanation as to why learners achieve, or fail to achieve, in a subject such as Mathematics, one must acknowledge that the causal factors are numerous (Singh et al., 2002) and much broader than the scope of this study. Therefore, the researcher has chosen to use SDT to focus, *in part*, on what she considers universal to all learners, namely their level and type of motivation. Addressing learners' psychological needs and the measure of internalisation and integration that occurs in the classroom are included in this discussion.

Any achievement is the product of some form of input or motivation response to the stimuli (Ryan & Deci, 2000b). Inputs are provided by educators, the school environment and parents, as well as the learner's own perceptions of self. The learner's type and quality of response to these inputs contribute significantly to the level of achievement reached in any particular subject (Ryan & Deci, 2000b). A description of SDT and how it relates to learners' achievement follows.

3.2.1 Motivation, Regulation and Achievement

Bandura and many earlier motivation theorists viewed motivation as a unitary phenomenon where a distinction is made between amotivation and motivation (Ryan & Deci, 2016). By contrast, SDT distinguishes between three main types of motivation, namely amotivation, extrinsic motivation and intrinsic motivation. Table 3.1 illustrates a continuum representing the distinction between these types of motivation. Amotivation causes non-action or lethargy as a result of factors, such as an individual not seeing the value of an activity or having perceived incompetence and therefore having no intention of doing the task. Extrinsic and intrinsic motivation, on the other hand, do result in action (Deci & Ryan, 2002). Extrinsic motivation can be divided into four categories based on the degree of autonomy and internalisation of values. The four categories' regulatory styles are external regulation, introjected regulation, identified regulation and integrated regulation.

Table 3.1: The self-determination continuum showing types of motivation, types of regulatory styles, loci of causality, corresponding processes and levels of autonomy (adapted from Ryan & Deci, 2016:102)

Motivation type	Amotivation	Extrinsic motivation				Intrinsic motivation
Regulatory style	Non-regulation	External regulation	Introjected regulation	Identified regulation	Integrated regulation	Intrinsic regulation
Level of motivation	Lack of motivation	Controlled motivation		Autonomous motivation		
Perceived locus of causality	Impersonal	External	Somewhat external	Somewhat external	Internal	Internal
Corresponding processes	Non-intentional Non-valuing Incompetence Lack of control	Compliance External Rewards and punishments	Self-control Ego-involvement Internal rewards and punishments	Personal importance Conscious valuing	Congruence Awareness Synthesis with self	Interest Enjoyment Inherent satisfaction
Level of relative autonomy	Lowest relative autonomy	⟷				Highest relative autonomy

External regulation, which is the least autonomous of the extrinsic motivation's regulatory styles, occurs when a learner has a low level of interest in the task and needs continual stimulus (reward or punishment) to remain motivated to participate in the activity (Guay, Chanal et al., 2010). *Introjected regulation* causes learners to be motivated out of obligation or guilt or to avoid disapproval or anxiety (Guay, Chanal et al., 2010). This behaviour can also be motivated by comparison to others, promoting self-esteem and ego-enhancing pride. Performance-oriented and test-focused schools promote this type of motivation. Learners who are motivated at these two levels will tend to take shortcuts and do just enough to satisfy the goal of a reward, gain approval or avoid punishment by a significant other. However, when learners identify with the worth of an activity, *identified regulation* comes into play. Through identification, learners find meaning in learning certain work. They cooperate because they see the benefit in doing the activity and not necessarily because it is interesting and, as a result, the level of engagement increases. The fourth and highest form of extrinsic motivation is *integrated regulation*. Integration takes place when these identified regulations become part of the self (Ryan & Deci, 2000a). The more an individual internalises the reasons for a response and incorporates these into the self, the more his/her extrinsically-motivated actions become self-determined (Ryan & Deci, 2000a). These regulations align with the individual's own life goals. Therefore, even though the action is extrinsically motivated, it is still authentic (Ryan & Deci, 2016). This form of motivation is closely related to intrinsic motivation as both are autonomous. The difference is that an action motivated by integrated regulation is performed because of an outcome that is separate from the action (*externally regulated*) even though it is valued by the individual whereas intrinsically-motivated behaviour is *internally regulated* because of interest in or enjoyment of the activity (Ryan & Deci, 2000a; Guay, Chanal et al., 2010).

The more learners are externally regulated, the less interest is shown; they value the activity less and put in less effort. They also are inclined to disown responsibility for underperformance, blaming an entity outside of themselves for the negative outcome (Ryan & Deci, 2000b; Dweck, 2002). Even unpleasant or uninteresting activities in a subject need to be valued and self-regulated by learners without external coercion to do these on their own. When motivation is self-regulated and not controlled externally, the individual displays more interest and confidence in the task. This translates into enhanced performance, resilience and creativity. For example, a learner may want to pursue a career where a high Mathematics mark is a prerequisite. Due to the value attached to this, the learner may study his/her Mathematics with volition even if he/she finds it uninteresting (Deci & Ryan, 2002) .

Extrinsic motivation varies considerably in its relative autonomy (Vallerand, cited in Ryan & Deci, 2000b). To illustrate, a learner who wants to achieve high marks for his/her final Grade 12 exam may do so in order to gain entrance to a post-matric course. Such a learner is motivated extrinsically because of the value he/she attaches to a chosen career. Another learner, who may also be extrinsically motivated, is one who is pressurised by his/her parents to work hard. The former is motivated due to personal choice as opposed to the latter, who is compliant because of external regulation. Even though both represent extrinsic motivation, they differ in their relative autonomy (Grolnick, Ryan & Grolnick, 1987).

Learners could engage in activities whether they are extrinsically or intrinsically motivated. However, this involvement may not always be evident or sustained unless the learners' psychological needs are met.

3.2.2 Psychological Needs

Ryan and Deci (2000b) assert that learners' psychological needs must first be met for integration, internalisation and, consequently, autonomous motivation to manifest, all of which are necessary for optimal classroom achievement. These psychological needs, which include a sense of autonomy, perceived competence and feelings of relatedness (Ryan & Deci, 2016) are discussed below.

3.2.2.1 Sense of autonomy

Autonomy, in this sense, does not mean independence or individualism. Rather it implies that the individual controls the motivation to respond and has a sense of *taking ownership of action* in the specific domain (Ryan & Deci, 2000b). There is evidence that over-control of learners, where learning is regulated through external incentive or pressure, reduces achievement in the long term (Grolnick et al., 1987; Garon-Carrier, Boivin, Guay, Kovas, Dionne, Lemelin & Tremblay, 2016). Deci and Ryan (2016) agree that external rewards tend to undermine autonomy and thus cause learners to revert to controlled forms of motivation as external and introjected regulation work against the individuals' self-regulation. However, when autonomous behaviour (e.g. enjoyment, freedom of choice) is encouraged in the classroom, the learner is more likely to be autonomously motivated to learn and persist (Garon-Carrier et al., 2016). Teachers who provide autonomous support by giving learners supportive feedback, providing structure by organising the classroom to promote competence and offering choices develop intrinsic motivation in learners. When learners are autonomously motivated, they identify with the significance or value of the action. In addition, their performance is enhanced, and the positive effects of the action are longer lasting than for those who do not receive autonomous support (Ryan & Deci, 2016). This underscores the importance of developing autonomous motivation during primary school (Guthrie et al., 2000; Guay, Ratelle et al., 2010).

3.2.2.2 Perceived competence

Perceived competence relates to learners' self-perception of their ability at school or in a specific domain. The concepts of perceived competence and self-efficacy are often used interchangeably (Rodgers et al., 2014). However, they differ in that self-efficacy is concerned with the individual's self-perception of his/her capability to take a course of action to achieve a goal in a *specific* task. Perceived competence, on the other hand, does not merely refer to some ability to do an activity, but factors in the *personal significance* of the task (Rodgers et al., 2014). Hence, interpersonal events and actions that increase the *feeling* of competence can increase the extrinsic or intrinsic motivation for that action due to the psychological desire for competence (Ryan & Deci, 2000b).

When accompanied by support for autonomy, perceived competence increases autonomous motivation (Guay, Ratelle, et al., 2010). In such cases, the learner will likely take ownership of an activity as a result of having a sense of being able to do it. At the same time, he/she will identify the personal value thereof and, in so doing, justify engaging in it. The manner in which learners are praised can influence their perceptions of competence. For example, if a teacher praises a learner by saying, “Good job. You did exactly as you were told,” the learner will not feel like the initiator of his/her own action, which could cause him/her to have a diminished sense of autonomy and therefore also a reduced feeling of competence. External rewards, as well as praise that is perceived as controlling, potentially reduce learners’ sense of ownership of behaviour, resulting in a reduced feeling of autonomy. Deci and Ryan (2002) stress that if a learner feels competent, he/she could be motivated. This motivation could be either extrinsic *or* intrinsic. However, it is only when this feeling of competence is *accompanied by autonomy* (his/her feeling a sense of ownership for the behaviour) that he/she will be intrinsically motivated. For example, if the teacher says, “I liked the way you used your initiative,” a message that the learner is autonomous and competent would be conveyed and thus intrinsic motivation would be heightened.

There are studies that have shown variations in perceived competence across learners’ schooling. Jacobs, Lanza, Osgood, Eccles and Wigfield (2002) assert that while some researchers (Wigfield et al., 1991) have observed a decline in the self-perception of competency in the transition to high school, this must be viewed as part of the larger downward trend from the middle of primary school through high school. Chouinard and Roy (2008) researched the change in competence beliefs of learners from Grade 7 to 9 and of Grades 9 to 11 learners. The learners who participated in their study had the option of changing to an easier Mathematics course at the end of Grade 11. Competence beliefs were found to be stable across Grades 7, 8 and 9, but showed a decline in boys from Grade 9 to 11 as they approached the choice between two Mathematics courses. They report that not only was there a decline year-on-year during this period, but also within each year, with the competence perception levels significantly higher at the start of a year than at the end.

3.2.2.3 Feeling of relatedness

There are instances where more than just a perception of competence or autonomy is required for a learner to engage in an activity. Over time, humans acquire a sense of connection with others in relationships or groups (Ruble, cited in Pfeifer & Peake, 2012), causing other extrinsic factors to motivate behaviour, such as wanting to receive appreciation or feeling connected to another human being (Deci & Ryan, 2002). This is referred to by Deci and Ryan (2002) as relatedness.

Ryan and Deci (2000b) assert that for an individual (such as a learner) to feel motivated to do an uninteresting or challenging task, having a connection with the person (such as a teacher or parent) requiring the task to be executed could increase motivation. They indicate that if teachers want to motivate learners to show commitment and have a high standard of achievement, an environment that fosters autonomy, competence and relatedness must be encouraged. It is in this context that internalisation and integration of values will be promoted.

3.2.3 Internalisation and Integration of Values

Motivation to engage in an activity is increased when taking ownership of an action, identifying with the personal significance of a task, and having feelings of relatedness. Internalisation and integration are more likely to occur spontaneously if these social-contextual conditions are present (Ryan & Deci, 2016). The SDT proposes that nurturing internalisation and integration of values and behavioural regulations is necessary if the learner is to be autonomously motivated.

Internalisation is the process of *accepting* a value or regulation. As internalisation (and degree of autonomy) increases, learners show increased persistence and an improved level of engagement. According to Deci and Ryan (2016), integration is the most mature type of extrinsic motivation because the individual *adopts* the value of the activity and makes it their own. Hence, this type of motivation is highly autonomous and has characteristics in common with intrinsic motivation. Learners operate at a higher level and are psychologically better adjusted when they have autonomous, internalised motivation and intrinsic motivation than if they were less autonomously motivated (Deci & Ryan, 2016).

3.3 PIAGET'S COGNITIVE THEORY

Jean Piaget was one of the most influential contributors to the field of cognitive development (Huitt & Hummel, 2003). Piaget's Cognitive Theory is a constructivist theory because it acknowledges that people construct their own knowledge as they build on prior knowledge and experiences. This differs from the theories of social constructivists, such as Vygotsky and Bruner who emphasise the role of the social context by maintaining that it is not possible to detach learning from its social setting (Murphy et al., 2012, cited in Newton & Alexander, 2013). Piaget proposed that children potentially go through four stages of cognitive development on their journey to adulthood. Piaget reasoned that the stages, none of which are omitted, follow chronologically and that cognitive development follows a specific sequence. A discussion of the four stages follows, with the emphasis on the third and fourth stages as these relate to the ages of the learners in this study.

The first stage is the sensorimotor stage, which occurs from birth to two years of age. Here, the child's learning about physical objects and the world around him/her involves all the senses. Concrete connections are made with everyday objects, such as a bottle giving food or a rattle making a sound (Williams, 2005). As the child's motor control improves, learning increases ((Papalia & Olds, 1981; Zhou & Brown, 2017). At the end of this stage, children realise that the things around them can be represented symbolically, using words and numbers. The gaining of symbolic understanding makes conceptual growth possible and is the catalyst for moving to the next stage of development, namely pre-operational thinking (Newton & Alexander, 2013). During the pre-operational stage (2-7 years), the child learns language and discovers that words are linked to objects. In so doing, the child increases his/her ability to attach symbols to physical objects (Wood, Smith & Grossniklaus, 2001).

The third stage is the concrete operational stage (7-12 years) during which the child begins to deal with abstract ideas, such as relationships between objects or concepts and numbers (Zhou & Brown, 2017). Cognitive development is expressed through the manipulation of symbols related to concrete objects in a logical and systematic manner. The child's understanding of his/her world occurs through logical thought processes and categories. During this stage of development, children are less egocentric and, as a result, have an increased awareness of events outside of themselves (Zhou & Brown, 2017). They start to realise that the views of others may differ from their own (Papalia & Olds, 1981). Concrete operational children have the ability to reverse their thinking (Papalia & Olds, 1981).

Piaget coined the terms conservation and transitivity, based on his observations of children in the concrete operational stage. Conservation is the ability to recognise that two equal quantities of a substance remain equal (in volume, mass, number, length or weight) if the substance is re-arranged, but nothing is added or taken away. This is a skill which learners will not have at first. Gradually, however, their ability to realise the interrelationships between dimensions, such as height and width improves. Eventually, two relationships will be considered simultaneously. Transitivity is connected to conservation. This is where a child recognises the relationship of two objects to a third and can comment successfully on the relationship between the two objects based on each relationship to the third. Children come to realise that more than one factor can play a role in any given situation (Papalia & Olds, 1981). Concrete, hands-on learning experiences are crucial for learning and progression through this stage if learners are to fully grasp these relationships (Zhou & Brown, 2017).

The formal operational stage is usually only reached at 12 years of age or later. During this stage, adolescents use symbols linked to abstract concepts. A range of variables can be considered in systematic ways, and abstract relationships and concepts can be understood (Zhou & Brown, 2017). Scientific and hypothetico-deductive reasoning are possible. This allows the individual to suggest what might be true rather than basing an opinion on concrete evidence. Kohlberg and Gilligan (cited in Papalia & Olds, 1981) assert that almost half of adults in the USA never reach this stage. Kuhn, Langer, Kohlberg and Haan (cited in Huitt & Hummel, 2003) support this finding by maintaining that only 30-35% of learners in their final year of high school have reached the cognitive development of the formal operational stage. Maturation provides the platform for formal operations to be established, but Huitt and Hummel (2003) insist that the environment must be conducive to this development if most adolescents are to attain this stage.

When contrasting Piaget's theory with those of other cognitive theorists, various observations can be made. Jerome Bruner was another monumental cognitive theorist and although he was influenced by Piaget, he did not agree with Piaget's theory in its entirety. While, for example, Piaget considered cognitive development to be a promoter of language use, Bruner maintained the reverse, claiming that language development leads to cognitive development. They also differed in that Piaget believed that children could not be forced into the next stage and that waiting for the child to be ready to learn more advanced concepts was ideal. Conversely, Bruner claimed that the cognitive development process could be sped up by adult intervention and promoted the view that a child's learning can be accelerated through the use of effective scaffolding (Newton & Alexander, 2013). Bruner argued that schools wasted too much time postponing concepts because they were deemed too difficult. If concepts that are too challenging for learners are taught, then they need to be revisited until the learner has fully grasped the work.

Even though Piaget's theory still has a major impact on the way in which cognitive development is viewed, it has come under some criticism. Wood et al. (2001) highlight some of these: Piaget has been criticised for underestimating the cognitive skills of young children because he used tasks that were too complicated for them. Critics claim that if simpler activities that test the same type of thinking were used when the theory was established, children would have been able to perform the tasks. His reasoning that thinking will be the same across all tasks within a specific stage (i.e. that if a child is in the concrete operational stage, then all thinking will be concrete across all activities) was also challenged. Wood et al. (2001) confirm that research shows a variety of thinking across cognitive activities. Newton and Alexander (2013) report a third criticism. According to Piaget, it would be fruitless to force children to learn mathematical concepts beyond their cognitive level, and children should progress to the end of a stage and into the next through exploring their world gradually. Some researchers have found that children can be helped to progress to more advanced mathematical thinking, especially in their practical knowledge, more rapidly than Piaget had proposed. Another criticism is that Piaget's theory does not emphasise the child's social world. Newton and Alexander (2013) defend these criticisms and argue that Piaget was not given sufficient recognition for describing the typical behaviour of children, namely what the majority of children would do under most conditions.

Despite these criticisms, however, Piaget's theory of cognitive development is used as part of the theoretical framework of this study for several reasons. Firstly, the first two stages (where, according to some critics, children's abilities have been underestimated) fall outside of the age range of this study, while those in the third and fourth stages relate almost perfectly to learners in the primary and high school respectively. Secondly, the acknowledgement that not all children reach the formal operational stage may contribute to the explanation as to why certain learners do not make significant progress in mathematics in high school. Thirdly, it may also assist in justifying why some learners excel when moving from Mathematics in Grade 9 to Mathematical Literacy in Grade 10. Studying mathematics depends on the learner's ability to build successive concepts based on those that came before whereas successful internalisation of these concepts requires exploration. This approach suits Piaget's views.

3.4 CONCLUSION

This theoretical framework provided the backdrop for possible reasons for learners' performance at school. The following chapter describes the methods employed to process and, ultimately, analyse the data.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

The aim of this research was to explore the longitudinal profile of performance in mathematics over 12 years of schooling, and to relate these findings to later achievement in Mathematical Literacy for those who chose this subject instead of Mathematics in the FET Phase. Data in the form of an annual Mathematics or Mathematical Literacy promotion mark were collected and analysed for this purpose.

The research design, which includes justification for the choice of cohorts, is clarified in the first section, after which the research questions are reiterated, and the case explained. This is followed by a detailed discussion of the cohorts, a description of the research instruments used and data collection procedures. Thereafter, an account of how the data were edited to accommodate variation in the form of the marks (percentages, levels and symbols) that were recorded by the school and how missing data were managed is provided. A description of the ways in which the data were analysed, using a Mixed Model for Repeated Measures (MMRM) and regression analysis is presented in Section 4.8. This chapter ends with a brief discussion of the ethical considerations involved, along with concluding remarks.

4.2 RESEARCH DESIGN

The research took the form of a survey-based case study of an ex-Model C school, thus allowing for comparative analyses as well as correlation-based research. Non-probability purposive sampling (Plowright, 2011) was applied. The decision to study an ex-Model C school was purposeful as seen in the reasons provided in Section 1.2. This empirical study is informed by the post-positivist paradigm (Mertens, 2010). The post-positivist paradigm was selected since more than just the empirical data is required for learners' mathematics performance over time to be understood (Scotland, 2012). In other words, while the researcher maintained objectivity, she was also aware of the subjective nature of the reasons behind the findings.

Positivists criticise the post-positivist outlook by claiming that the methods used by the latter include a collection of personal impressions. These are viewed by positivists as being too subjective and influenced by researcher bias. Post-positivists counteract this argument by asserting that reality is not a fixed entity existing in a vacuum, but rather is influenced by context, which the present study is. They argue that positivists provide only one component of reality (Maree, 2007).

In post-positivist research, contributing relationships are also taken into consideration when interpreting the findings (Scotland, 2012), and when human behaviour (or as in this case, the results of learners' actions) is being investigated, possible underlying causes need to be examined. Some of these variables may be hidden initially and only come to the fore when their effects are evident (House, cited in Scotland, 2012).

Once the findings of the present study were known, possible explanations for these were investigated based on the literature. However, a scientific study of variables influencing human actions is never complete (Berliner, 2002) and, when considering factors that affect learners' performance over their entire school career, the variables are countless. Since this research is based on archived data and no records of influencing factors were kept, this study does not attempt to identify or research all these factors. Instead, it aims to elucidate, by means of the literature, possible reasons for the findings.

4.3 RESEARCH QUESTIONS

The following research questions were formulated in order to guide this study:

Primary research question: What is the longitudinal profile of mathematics performance of boys attending a South African ex-Model C, single-gender school?

Secondary research questions:

- How does mathematics performance change through the course of schooling for learners who take Mathematics to Grade 12 as opposed to that of those who take Mathematical Literacy?
- How effectively does learners' mathematics performance in lower grades predict their mathematics performance in higher grades?

4.4 THE CASE

According to the Trends in International Mathematics and Science Study (TIMSS) findings in 2015 (Reddy et al., 2016), it is not only previously-disadvantaged schools that are underperforming in Mathematics: when compared to other countries, ex-Model C schools also underachieve. Therefore, learner performance at the latter schools also needs to be researched.

The decision to conduct research on the ex-Model C school used in this study was partly based on convenience as it provided the researcher with easy access. Moreover, it was partly purposeful, given the low teacher turnover at this school. The fact that the same teachers had been teaching particular grades over much of the period included in this study improved the validity of the data across the cohorts. Furthermore, to enable comparisons regarding achievement across various grades and to make reliable deductions after analysis, it was essential to collect as complete a set of data as possible. Thus, a school that has well-archived, accessible data was chosen.

4.5 COHORTS

Eight cohorts were selected, each of which were comprised of a group of learners who began their schooling (Grade 1) in a specific year and concluded their schooling in Grade 12. These cohorts are not true cohorts as some of the learners entered or left a cohort due to repetition of a grade or because they had not attended this particular school for part of their schooling.

The manner in which this was dealt with is discussed in Section 4.7, which focuses on data management.

The first cohort (Cohort 2009) entered Grade 1 in 1998 and matriculated in 2009, hence the label ‘Cohort 2009’. The cohorts began their schooling in consecutive years from 1998 to 2005. The eighth cohort (Cohort 2016) entered formal schooling in 2005 and completed Grade 12 in 2016. For ease of reference, the cohorts, together with the year in which their formal schooling began and the year in which they matriculated are shown in Table 4.1.

Table 4.1: The number of learners and years of schooling for each of the eight cohorts (n=684)

Cohort	Number of learners	Year in Grade 1	Year in Grade 12
2009	84	1998	2009
2010	90	1999	2010
2011	73	2000	2011
2012	84	2001	2012
2013	80	2002	2013
2014	84	2003	2014
2015	95	2004	2015
2016	94	2005	2016

4.5.1 Motivation for Choice of Cohorts

In 1997 national policy changed regarding the age of school entry. Hence, cohorts from 1998 onwards were selected. Consequently, the learners in these eight cohorts all began their schooling at the age of six, turning seven in Grade 1 instead of starting at the age of five and turning six in Grade 1 as was previously the case (South African Schools Act, 84 of 1996). Another justification for the choice of cohorts is that at the end of 2007, the form of Mathematics as a subject had changed in the South African school system. Up to the end of 2007, Grade 12 learners wrote Mathematics on the higher or standard grade level, with Mathematics being optional (Taylor, 2012).

In 2006, in an attempt to improve literacy in mathematics nationally, two options were introduced to Grade 10 learners. These learners were given the option of taking Mathematics (with no distinction in terms of difficulty in the form of higher and standard grade as had previously been the case) or Mathematical Literacy (Reddy, Van der Berg et al., 2012). Since the data used in this study were based on the results of learners who had matriculated between 2009 and 2016, all learners were either taking Mathematics or Mathematical Literacy during the FET Phase (Cranfield, 2012).

Simkins (2010) attempted to equate Higher Grade Mathematics in 2007 with Mathematics in 2008 and found that a mark of 40% for the former was on par with 54% for the latter. This disparity was yet another reason not to include cohorts that matriculated prior to 2008 in this study.

4.5.2 Explanation of Marks Retrieved from the Archives

The data comprising the final Mathematics and Mathematical Literacy promotion marks were retrieved from the school's archives. Thus, the promotion marks of learners who chose Mathematical Literacy instead of Mathematics in the FET Phase also formed part of the data set.

The promotion mark is the final mark obtained by a learner at the end of each grade. This mark is calculated, using the marks obtained throughout the year in the subject (from continuous school-based assessment tasks, such as projects, tests and examinations) as well as the mark obtained in the final examinations. The promotion mark was used because it encompasses each learner's performance in several forms of assessment and is the most comprehensive mark that accurately reflects a learner's overall achievement in any given year. The weighting of the school-based assessment tasks in relation to the final examinations may have varied across cohorts, which may have affected the relative marks of the successive cohort to some degree. However, this does not invalidate the search for correlations between the grades since the weighting criteria were applied to all learners in a class.

The promotion mark for Grades 1 to 11 was the final mark as indicated on the promotion schedule prepared for the Department of Basic Education (DBE) at the end of each year. These marks were recorded in different ways (symbols, Levels 1-4 or 1-7, percentages) as stipulated by the DBE. All marks that were not recorded as a percentage were converted to a percentage. The way in which this was dealt with will be discussed in Section 4.7, which focuses on data management. The Grade 12 marks consisted of the final percentage as indicated on the learners' matric certificates after the re-marking of examination scripts (as requested by learners).

4.6 RESEARCH INSTRUMENTS AND DATA COLLECTION

The 1998-2008 data were obtained from archived hard copies of the promotion schedules at the school. From 2009, the school used the South African School Administration and Management System (SA-SAMS) to record data digitally. Hard copies of the promotion schedules and SA-SAMS were used to obtain promotion marks from 2009 to 2016. All the data were captured in Excel in preparation for statistical analysis.

4.6.1 Validity and Reliability

Since the present study spanned 19 years, using archived data was the only means of accessing information regarding the learners' performance during this period. In order to maintain a high level of validity, the mark that incorporated the widest range of skills and the highest number of assessments in a particular year, namely the promotion mark, was selected.

The data were read in with the aid of an assistant. The number of records (learners) per grade and cohort were crosschecked. Spot checks were carried out by the researcher and the assistant to ensure that there were no errors in the data that had been captured and which would compromise the validity thereof.

Appendix A shows the form (symbols, levels or percentages) in which the DoE required the promotion mark used in the data set to be recorded. Learners in the lower grades, especially early in the data set, were only awarded one of four symbols (n, p, a or b). Later, Levels 1-4 and, subsequently, Levels 1-7 replaced this system. For the high school, the majority of the promotion marks were recorded as percentages. An explanation as to how these symbols, levels and percentages were used in the data set follows.

4.7 DATA MANAGEMENT

Data editing was necessary for three main reasons. Firstly, the manner in which the data were recorded (symbols, Levels 1-4 or 1-7, percentages) varied over the 19 years. Secondly, any marks obtained by the learners while attending a school other than the one used in this study were not used in the data set. Lastly, some of the learners changed from Mathematics to Mathematical Literacy in Grade 11 or 12, resulting in 'missing' Mathematical Literacy data for Grades 10 and/or 11, when these learners previously still took Mathematics.

4.7.1 Interval-Censored Data

The majority of the marks obtainable for primary school (Grades 1 to 7) were not available as percentages. Instead, they were recorded only as symbols (n, p, a or b), each representing an interval of percentage values. Therefore, these marks were interval-censored. In order to attach a specific percentage to a certain symbol, the percentage midpoint of the interval associated with each symbol was calculated and used for the relevant primary school data. Table 4.2 shows the relevant midpoints for each symbol.

Table 4.2: Summary of the description of symbols awarded for levels, percentage range and the relevant midpoints

Description	Level	Percentage range	Midpoint
Not achieved	n	0-39%	19.5%
Partly achieved	p	40-59%	49.5%
Achieved	a	60-79%	69.5%
Achieved beyond	b	80-100%	90%

In 2004, the grading system changed, and Grades 1-3 were given levels (1-4) instead of symbols (n, p, a and b). The following year, the grading system, based on Levels 1-4, was applied to Grades 1-5. This was extended in 2006 to include Grades 6 and 7. Again, a midpoint for each of these levels was determined (as indicated in Table 4.3) and applied to the data concerned.

Table 4.3: Summary of the description of levels (1-4) awarded, percentage range and the relevant midpoints

Description	Level	Percentage range	Midpoint
Not satisfied	1	0.01-34.99%	17.5%
Partly satisfied	2	35.00-49.99%	42.5%
Satisfied	3	50.00-69.99%	60.0%
Exceeded	4	70.00-100.00%	85.0%

On the other hand, learners who were in Grade 7 or 8 in 2007 or in Grade 7, 8 or 9 in 2008, were awarded a level (1-7) based on their performance in Mathematics during that year. The midpoint for each of these levels (as shown in Table 4.4) was used to convert all the data into a percentage.

Table 4.4: Summary of the description and symbols awarded for levels (1-7), percentage range and the relevant midpoints

Description	Level	Symbol	Percentage range	Midpoint
Not achieved	1	FF	0-29%	14.5%
Elementary achievement	2	F	30-39%	34.5%
Moderate achievement	3	E	40-49%	45.5%
Adequate achievement	4	D	50-59%	54.5%
Substantial achievement	5	C	60-69%	64.5%
Meritorious achievement	6	B	70-79%	74.5%
Outstanding achievement	7	A	80-100%	90.0%

Two learners' data were removed from the data set as these learners fell outside the parameters of the study: one of these learners started schooling prior to 1998; the other was in Grade 11 in 2016. If a learner repeated a year, the promotion mark obtained at the end of the second year in that grade was used.

4.7.2 Missing Data

Several learners' records for Mathematics and Mathematical Literacy over their school careers were incomplete, resulting in 'missing data'. The reasons for the missing data could include the following:

- The learners attended another school for part of their schooling;
- The learners did not take Mathematical Literacy in Grades 10 and 11, but took it in Grade 12, resulting in 'missing' Mathematical Literacy marks for Grades 10 and 11; or
- The learners switched from Mathematics to Mathematical Literacy in Grade 11 or 12, causing the Mathematics marks to be 'missing' subsequent to the switch.

The way in which these 'missing' marks were dealt with statistically will be discussed in the following section.

4.8 STATISTICAL ANALYSIS

4.8.1 Descriptive Statistics

Marks achieved by learners from Grades 1 to 12, though not necessarily for all 12 years, and resulting in a mark for Mathematics or Mathematical Literacy from Grade 10 to 12, though not necessarily for all 3 years, were available for 684 learners while attending this school. Of these learners, 302 matriculated with Mathematics and 160 with Mathematical Literacy. The remaining 222 learners attended the school for part of their schooling but did not matriculate at the school. Therefore, no Grade 12 Mathematics or Mathematical Literacy marks were available for these learners and the latter group of 222 was not used in the study.

There are fundamental differences between the curriculum and academic standard of Mathematics and Mathematical Literacy in Grades 10 to 12. Therefore, the learners were classified into the following two sets:

- Learners who took Mathematics to Grade 12 (M-set): These learners had a Mathematics mark in Grade 12 and therefore comprised the set of learners who took Mathematics in matric – a fact that could be established directly by examining the database. This set consisted of 302 learners.
- Learners who took Mathematical Literacy in Grade 12 (ML-set): These learners had at least one Mathematical Literacy mark in Grades 10 to 12. Thus, it is evident that this set of learners did not take Mathematics in matric. Once again, this was established by examining the database. (Note that in the event of any of these Mathematical Literacy learners taking Mathematics in Grade 10 or 11, these Mathematics marks were not included in the statistical analysis of Mathematical Literacy marks; where relevant, data imputation was performed to compensate for the absent Mathematical Literacy marks – see Section 4.8.2 for details.) This set consisted of 160 learners.

The descriptive statistics (mean, standard deviation, minimum, median and maximum) for the M- and ML-sets are provided in Appendix B. The two sets presented above are complemented by the following set:

- Learners fulfilling both of the following conditions: no Mathematics mark in Grade 12 and no Mathematical Literacy marks in Grades 10 to 12 (Unknown set): These learners either have no mark at all in Grades 10 to 12 (due to leaving the school prior to the end of Grade 10) or only have Mathematics marks in Grades 10 and 11, but not in Grade 12. These learners did not matriculate at the school. Therefore, there was no evidence of a Grade 12 Mathematics or Mathematical Literacy mark, resulting in the researcher not being able to establish whether these learners matriculated with Mathematics or Mathematical Literacy. This set consists of 222 learners.

4.8.2 Mixed Model for Repeated Measures (MMRM)

The data were analysed, fitting an MMRM. Repeated measures mean that more than one datum per individual subject (learner) is documented (Cheng et al., 2005). In the present study, these observations occur over time, and observations pertaining to the same learner are assumed to be correlated (Littell, Pendergast & Natarajan, 2000). In the case of this research, the Mathematics or Mathematical Literacy mark recorded each year was the trait (dependent variable) analysed while each learner was the subject that had been measured repeatedly. Thus, for each learner, up to 12 repeated measurements were available.

The "Proc Mixed" procedure from the statistical software package SAS Enterprise Guide version 7.4 (SAS, 2017) was used to analyse the data. This allowed fitting the MMRM with an unstructured covariance matrix for repeated measures within learners. The MMRM was fitted, using Restricted Maximum Likelihood (REML), fitting fixed effects of cohort, grade and grade within a cohort.

An MMRM remains valid when missing data are "missing at random" (MAR). In the literature, MAR is central in statistical analysis with missing data. The observed data values, as well as the pattern of missing values, must be considered when making inferences, using incomplete data (Seaman, Galati, Jackson & Carlin., 2013). In that sense, the MMRM is an effective way of handling the problem of missing data in this data set (Krueger & Tian, 2004). Furthermore, fitting the MMRM enabled both secondary research questions to be addressed.

The MMRM analysis implicitly imputes missing data, and estimates the academic performance as follows: In the analysis of the Mathematics marks of the M-set (Mathematics Grades 1-9 and Grades 10-12), missing data were imputed as though the learner had taken Mathematics in the years for which the data are missing. Thus, the analysis reflects the Mathematics performance (over time) of learners who took Mathematics rather than Mathematical Literacy to Grade 12. By contrast, the missing data of the ML-set (Mathematics Grades 1-9 and Mathematical Literacy Grades 10-12) were imputed as though the learner had taken Mathematical Literacy in the years for which the Mathematical Literacy data are missing. The Mathematical Literacy performance (over time) of learners who took Mathematical Literacy as opposed to Mathematics up to Grade 12 is shown in the results of the analysis.

In its basic form, the MMRM was fitted to the Mathematics and Mathematical Literacy marks (dependent variable) with the following fixed effects in the model:

- Cohort (eight cohorts, 2009-2016);
- Grade (12 levels, Grades 1-12); and
- Grade in cohort interaction term.

An unstructured (UN) covariance matrix was fitted to the 12 repeated measurements. An UN covariance matrix makes no assumptions regarding the values of the variances and covariances, allowing each value to be estimated individually from the data (Al-Marshadi, 2007). REML was used to estimate parameters and to test the fixed effects of cohort, grade and grade within a cohort for inclusion in the final model. REML is a well-established method for this purpose (Kenward & Roger, 1997). Standard errors and degrees of freedom were calculated, using the Kenward-Roger method for mixed models, which has been shown to be effective in cases of missing data (Chawla, Maiti & Sinha, 2014).

Based on the MMRM, Least Squares Means (LSM) were calculated for Mathematics and Mathematical Literacy marks for each grade, for each of the eight cohorts, and for the combination of each grade by cohort. LSMs are means that are calculated based on the fitted mixed linear model. They are suitable for this particular purpose and for application in this research as they account for the missing data. When reference is made to 'mean' or 'average' marks based on an ANOVA of the mixed model, the researcher is referring to the least squares means estimated based on the models used.

Obtained variances and covariances were used to calculate correlations between the marks of the various grades. The strength of this approach is that various statistical analyses could be applied to a single group of learners across 12 years of schooling. This allowed for the tracking of learners' progress, thus providing insight into their mathematics achievement over an extended period.

4.8.3 Regression Analysis

Regression analysis allows researchers to make predictions. Therefore, in order to establish the effectiveness of the prediction of marks and, in so doing, answer Secondary Research Question 2, regressions needed to be done on the data.

4.8.3.1 Data sets for regression analysis

To prepare the data for regression analysis, multiple imputation (MI) was used to impute missing values of Mathematics and Mathematical Literacy marks, using the fully conditional specification method (SAS, 2017).

For the M-set, MI was carried out, using the available Mathematics promotion marks in Grades 1 to 12 and the categorical variable "year in Grade 1". For the ML-set, MI was carried out, using the available Mathematics promotion marks in Grades 1 to 9, the available Mathematical Literacy promotion marks in Grades 10 to 12 and the categorical variable “year in Grade 1”. In this way, 100 data sets with imputed missing values were created for each cohort.

For the M-set, linear prediction equations of Mathematics marks in Grades 2 to 12, based on the Mathematics marks in previous years, were established. Similarly, for the ML-set, linear prediction equations of Mathematics marks in Grades 2 to 9, and of Mathematical Literacy marks in Grades 10 to 12, based on Mathematics marks (Grades 1 to 9) and Mathematical Literacy marks in previous years (Grades 10 and 11), were derived.

4.8.3.2 Prediction of marks

For all imputed data sets, Mathematics and Mathematical Literacy marks for Grade 2 and higher were regressed, in simple linear regressions, against the marks from lower grades (one lower grade mark at a time). The regression intercept and slope were based on the 100 imputed data sets, which had been averaged.

4.9 ETHICAL CONSIDERATIONS

The data used in this study were recorded in the years prior to this investigation. Any data collected were taken from existing sources, such as SA-SAMS and the school’s archives. No learners or teachers were involved in the process.

While the names of individual learners were listed on the Excel spreadsheet to facilitate the compilation of the data set, each learner was allocated a code for analytical purposes. Thus, each learner remained anonymous and any deductions made were assigned to the groups of learners investigated, namely the M-set and ML-set, rather than any particular individual.

Ethical clearance was obtained from the DBE, the principal of the school concerned as well as from the University of the Free State to conduct this study (ethical clearance no. UFS-HSD 2017/0727). The relevant documents appear in Appendices E, F and G.

4.10 CONCLUSION

This chapter began with an outline of the research design, followed by the research questions and a description of the case. Next, a detailed explanation of which cohorts were included in the research as well as the reasoning behind the choice of cohorts was provided. This was followed by a description of the research instruments and data collection procedures used, with particular emphasis on the validity of the research and the reliability of the data. How the data were edited and the reasons as to why some of the data were missing were explained. Subsequently, the statistical analysis, which included the descriptive statistics and statistical approach to the missing data, were elucidated. Regression analysis of data was examined, and the chapter concluded with a discussion of the ethical considerations. The results and findings of the MMRM analysis (mathematics performance over time) and the regression analysis (prediction of marks) are explained in Chapters 5 and 6 respectively.

CHAPTER 5

RESULTS AND DISCUSSION OF LONGITUDINAL PERFORMANCE OF MATHEMATICS AND MATHEMATICAL LITERACY SETS

5.1 INTRODUCTION

The purpose of this study was to examine the longitudinal changes in mathematics performance at an ex-Model C school for boys. Data relating to Mathematical Literacy performance were also analysed. This made it possible to investigate not only how performance in mathematics changed over time for learners who took Mathematics to Grade 12 (M-set), but also how it changed for those who initially also had Mathematics but matriculated with Mathematical Literacy (ML-set). Correlations between the various grades as well as the effectiveness of using the marks obtained in lower grades to predict performance in later grades were examined. The focus of this chapter is on the changes in Mathematics and Mathematical Literacy performance over the twelve-year period of learners' schooling. The discussion on the effectiveness of using the marks achieved in earlier grades to predict performance in subsequent grades will follow in Chapter 6. This data set was analysed, fitting a Mixed Model for Repeated Measures (MMRM), where up to 12 repeated measurements were available for each learner. The fixed effects of cohort, grade and grade within cohort were fitted, using Restricted Maximum Likelihood (REML).

This chapter begins with an examination of the M-set, where the results are reported followed by a discussion thereof. This is followed by a similar commentary on the ML-set. A comparison between the M- and ML-sets follows, where similarities and differences in performance between these two sets are identified. The reporting on the results of each of these three sections, namely the M-set, the ML-set and the comparison between the two, follows a similar layout. Each section begins broadly by briefly examining the variation in Least Squares Means (LSM) estimates of the eight cohorts. Subsequently, a closer view of performance per phase, followed by a detailed examination of the longitudinal performance across the 12 grades, are presented. Each section concludes with a discussion based on the aforementioned results.

5.2 LONGITUDINAL PERFORMANCE OF THE MATHEMATICS-SET

The M-set comprises 302 learners all of whom matriculated with Mathematics at the school. The results of the analysis of this data and the related discussion follow.

5.2.1 Results

5.2.1.1 Performance of the M-set across eight cohorts

In Figure 5.1 below, the Least Squares Means (LSM) estimate promotion marks as a percentage and the standard error (SE) of Mathematics promotion marks are shown for the eight cohorts (2009-2016). Least Squares Means (LSM) are means that are calculated based on a linear model, allowing a line of best fit to be determined. They are suitable for this particular purpose and for application in this research as they are not very sensitive to missing data. The term 'mean marks' will be used from here onwards instead of Least Squares Means estimate. The results show that the lowest mean mark was 66% (cohort 2016) and the highest 74% (cohort 2010), resulting in a range of 8%. Thus, the mean mark across the eight cohorts is relatively stable.

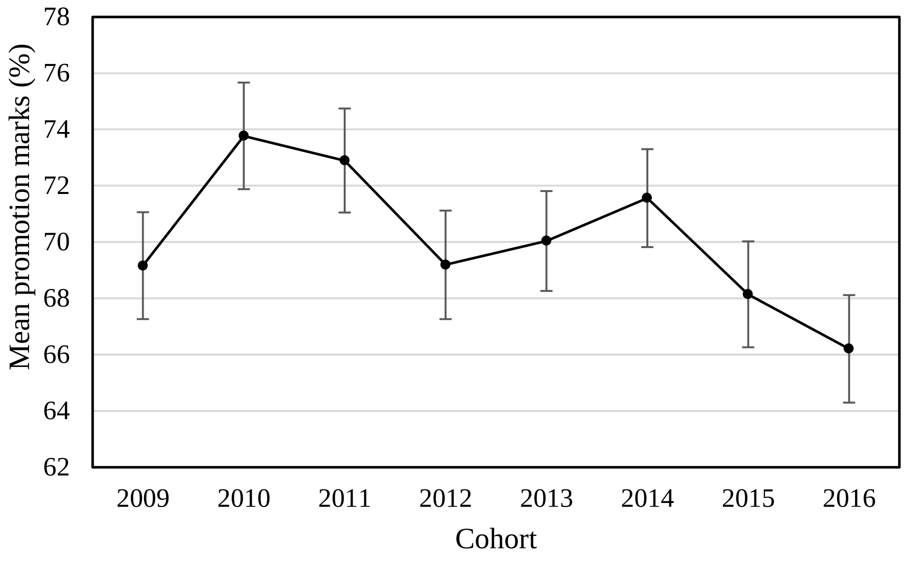

Figure 5.1: Mean promotion marks (%) and standard errors (SE) of all the learners in each of the eight cohorts (2009-2016) over their 12 years of mathematics instruction for the Mathematics set (M-set)

5.2.1.2 Performance of the M-set across phases

A summary of the longitudinal performance for the M-set from the Foundation Phase to the Further Education and Training (FET) Phase in Figure 5.2 shows that the mean mark in the Foundation Phase is 71% and increases slightly to 74% in both the Intermediate and Senior Phases. Thereafter, there is a steep decline of 12 percentage points in the FET Phase to 62%.

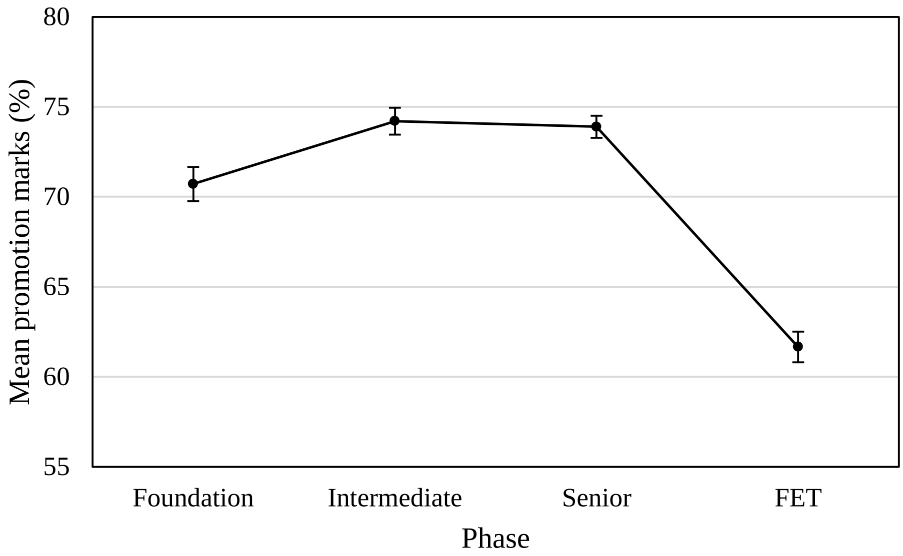

Figure 5.2: Mean promotion marks (%) and standard errors (SE) per phase of all the learners in each of the eight cohorts (2009-2016) for the Mathematics set (M-set)

The seemingly stable performance across the Intermediate and Senior Phases, as shown in the above graph, is deceptive. The individual grades in these two phases had varying mean marks, especially in the Senior Phase, which 'averaged out' to be similar to those in the Intermediate Phase. A detailed discussion on this aspect follows.

5.2.1.3 Performance of the M-set across grades

A summary of the mathematics performance of the M-set from Grade 1 to 12 is depicted in Figure 5.3 below. The marks in the first three years, namely from Grade 1 to 3, are stable. From Grade 3 to 4, the mean mark increases by 5 percentage points. From Grade 5 to 6, the mean marks drop from 76% to 73%, which is followed by an increase of 8 percentage points to 81% in Grade 7. The highest Mathematics mean mark across all grades is achieved in Grade 7.

From Grade 7 to 10, learners' marks show a sharp decrease. The M-set's Mathematics mark from Grade 7 to 8 declines by 8 percentage points from 81% to 73%. A further 4 percentage points drop occurs in Grade 9, and in Grade 10 the mean mark falls by another 8 percentage points to 61%. The greatest declines for the M-set, namely from Grade 7 to 8 and from

Grade 9 to 10, are virtually the same, but the factors influencing these noticeable drops may differ.

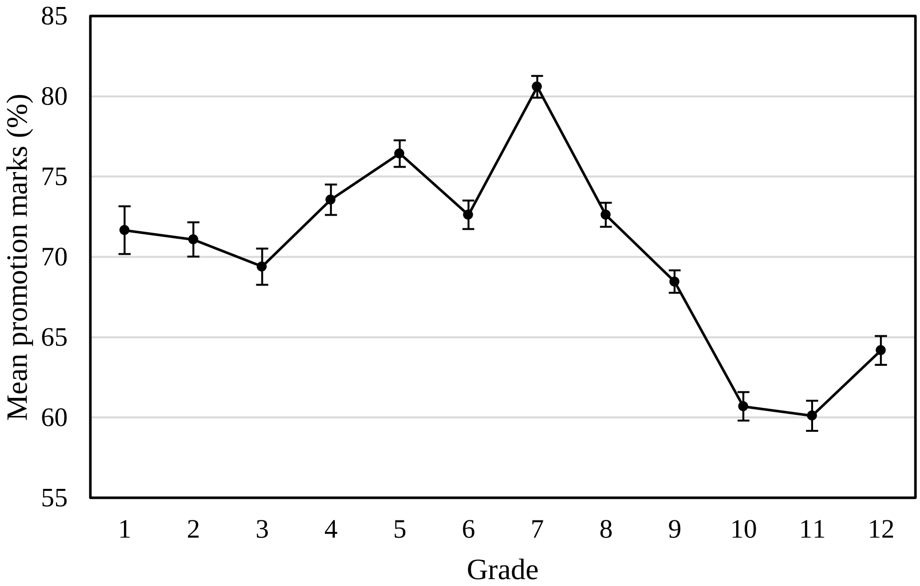

Figure 5.3: Mean promotion marks and standard errors (SE) per grade of all the learners in each of the eight cohorts (2009-2016) for the Mathematics set (M-set)

Marks are fairly constant from Grade 10 to 11, with Grade 11 having the lowest Mathematics mean mark (60%) across all grades. There is an upswing in marks of almost 4 percentage points from Grade 11 to 12, with the mean Mathematics mark in Grade 12 being 64%. These results show that on average, a learner achieves his highest mark for Mathematics in Grade 7 after which there is a significant decrease in marks (21%) up until Grade 11.

5.2.2 Discussion

5.2.2.1 Stable mean marks from Grade 1 to 3

In their first year of schooling, most learners tend to have an overly optimistic view of school (Eccles, 1999; Bouffard, Marcoux, Vezeau & Bordeleau, 2003), with high academic expectations as well as of their ability to cope. However, their judgements of self are not very precise or well-formed at this stage. This is partly because their skills base is increasing quickly, somewhat unrealistically boosting their self-concept (Eccles, 1999) and bolstering their intrinsic motivation (Liu & Koirala, 2009). This rapid rate of mastering tasks could increase learners' self-efficacy (Hannula et al., 2016). This self-efficacy might translate into learners not hesitating to try activities and having a heightened level of motivation, whether extrinsic (e.g. to please their parents or teacher) or intrinsic (e.g. enjoyment of school).

With the exception of one or two learners per cohort, all Grade 1 learners came from this school's pre-school. The majority of those learners spent at least one year in this school's pre-school. This particular pre-school has a very thorough and high standard of input, exposing learners to several concepts taught in Grade 1. These include categorising and sorting, concepts of time, counting, recognising patterns and comparing 2-D and 3-D shapes. This could account for the Grade 1 mean marks being higher than those for Grades 2 and 3. The fact that these learners were well prepared for Grade 1 could have heightened their level of self-efficacy. Higher self-efficacy levels, together with an optimistic self-concept (because of their overrated sense of self at this age) and belief that they can do what is required of them, may heighten learners' intrinsic motivation which, in turn, has a positive impact on their performance. Thus, this could account for the reasonably high mean estimate in Grade 1. Therefore, the self-efficacy of these young learners could have been influenced by both the rapid increase in learning due to leaps in their exposure to knowledge and skills, as well as by their actual achievement.

Teachers are generally nurturing in the Foundation Phase, increasing the feeling of relatedness in learners. Children in Grades 1 to 3 are often eager to please their teachers and parents. When these young learners experience nurturing and safety in the classroom under the teacher's care and parents are involved in their homework activities, introjected motivation may urge these learners to do their classwork and homework diligently. This form of extrinsic motivation is even more prevalent if there are rewards, such as star charts or special privileges, used in the classroom (Benabou & Tirole, 2003). At the school under study, regular contact opportunities are provided to maintain a close relationship and high level of communication between teachers and parents. The sense of relatedness would thus contribute to the level of performance remaining reasonably stable until Grade 3.

From a statistical perspective, the manner in which the data were recorded in the archives and the censoring of data could have influenced the mean mark for each of the grades in the Foundation Phase. The marks awarded were mostly in the form of one of four symbols, each representing a range of marks. Thus, a midpoint for each symbol was calculated.

5.2.2.2 The increase in mean marks from Grade 3 to 5

In the current study, the mean marks increased from Grade 3 to 4 and again from Grade 4 to 5. The increase of 7 percentage points in the mean marks from Grade 3 to 5 evident here, differs from the mean marks of the majority of learners in South Africa, who usually experience a decline in marks, especially from Grade 3 to 4 (Spaull, 2015; Graven, 2016). In a longitudinal study of numeracy performance from Grade 3 to 5 in previously-white South African schools, Coetzee (2014) found that numeracy test scores were stable from Grade 3 to 4, with an upswing in Grade 5. The picture is different in previously-disadvantaged schools where there is a decrease or no improvement in marks from Grade 3 to 4 (Coetzee, 2014). Many South African learners entering Grade 4 experience a change in the LOLT (Language of Learning and Teaching) to a language other than their mother tongue. This often means that they have to translate what the teacher is saying before they attempt to grasp and master the concept being taught. This slows down the learning process and could account, in part, for the mean marks of the majority of South African learners declining from Grade 3 to 4. Graven (2016) confirms that the Annual National Assessment (ANA) shows that there is a steady decrease in marks from Grade 1 to 3. This is followed by a steep decline from Grade 3 to 4 nationally (Department of Basic Education, 2014). In addition, most of these learners are far behind the curriculum standards for Mathematics. Although this DBE report was brought out after the learners in this study were in Grades 3 and 4, the decrease in marks for lower-quintile schools or the stability in marks for upper-quintile schools in these two consecutive grades has been consistent for many years (Department of Basic Education, 2014). In addition, Spaull and Kotze (2015) found that by Grade 3, learners attending the poorest 60% of schools are three years behind in terms of learning compared to those in wealthier schools.

Pretorius (2014) largely attributes the poor academic performance in Quintile 1 schools to poor literacy levels and the transition from home language to English or Afrikaans. While the improved performance from Grade 3 to 4 of the learners in the present study could, in part, be attributed to extended prior exposure to the LOLT, it cannot be assumed that the general decrease in performance nationally across these grades is mainly due to lack of teaching in the LOLT. Van der Berg et al. (2011) warn that the effects of language, socio-economic conditions and the level of school functionality are complex and therefore not easily separated.

However, the vast majority of the learners in the current study have had English as LOLT from Grade 00 or Grade R to 3. Therefore, the transition to Grade 4 would potentially be smoother for these learners than for those in the Quintile 1 schools in Pretorius' study, where the LOLT in Grades 1 to 3 is not English. This English language advantage, together with the wealth of the school, which allows for extra resources such as remedial intervention, may be causal factors for the learners' mean marks in this research improving from Grade 3 to 4.

On examination of the Grade 5 curriculum to which the learners in this study were exposed, the change in concept difficulty is not great and very few new concepts are introduced. Thus, there is more opportunity for consolidation in Grade 5. This could also account for the Grade 5 Mathematics mean marks being the second highest during the 12 years of schooling.

Hannula et al. (2014) found that in the lower grades, the prevailing effect is from achievement to self-efficacy. However, it is possible that (high) achievement and the lingering effects of leaps in exposure to knowledge and skills that a young learner experiences (Eccles, 1999) both have a (positive) effect on self-efficacy, although determining the extent to which each factor improves this aspect would need further research.

5.2.2.3 Decrease in mean marks from Grade 5 to 6

The Mathematics marks from Grade 3 to 7 increase year-on-year, except for Grade 6, where there is a decrease of nearly 4 percentage points from Grade 5. It is possible that the Mathematics curriculum for Grade 6 is a significant contributing factor. In Grade 6, numerous multi-step concepts and expansions of existing concepts are taught. These include fractions up to two decimal places, fractions with denominators that are multiples of one another and the concept of discount. Long division, using four-digit numbers and three-digit whole number dividends, as opposed to division of three-digit numbers by two-digit numbers in Grade 5, as well as algorithms for multiplication in columns were also taught (Department of Education, 2002). Each of these new concepts mentioned here not only requires a ready knowledge of times tables, but also involves using several *different* procedures *simultaneously*.

In geometry, more complex activities such as describing the relationships between 2-D shapes and 3-D objects in patterns are required while measurement includes the somewhat abstract concept of time zones. In data handling, learners are required to master the construction of pie charts, which requires a good working knowledge of fractions and the basic properties of a circle along with accurate use of equipment (Department of Education, 2002). These new concepts, along with the progression of concepts taught previously, considerably increase the cognitive demand on the learners. Not only are they required to apply previously-learned skills, but they also have to integrate several skills in a very specific order in a single task. For example, long division requires the ability to estimate fairly accurately, multiply numbers, write the correct numbers in the correct positions and subtract accurately while the learner uses his knowledge of times tables. This more challenging curriculum in Grade 6 (as opposed to that in Grade 5) could contribute to a lower performance level.

5.2.2.4 Peak in Grade 7

Learners in Grade 7 achieved the highest mean marks of all the grades. They are at the height of their primary school career. They are the most senior learners in the school and several of them are in positions of responsibility and/or in the top sports teams. The feedback they experience, which will generally be very positive (e.g. selection to provincial sports' teams, monitors), and comparisons of themselves in relation to the rest of the school, bolsters their self-concept (Shavelson & Bolus, 1982) and, in so doing, increases overall motivation levels.

The progression of the curriculum from Grade 6 to 7 is seemingly less challenging than from Grade 5 to 6. While some new concepts, such as integers and exponents are introduced in Grade 7, many of these are not combined with other mathematical processes. For example, learners are required to solve $4^3 = ?$ or $-8 + (-6) = ?$. This involves more straightforward practising of the basics of exponents or integers as opposed to some of the more complex Grade 6 concepts. In Grade 7, there are several practical sections, such as the drawing of simple graphs (e.g. bar graphs, line graphs and histograms), plotting on the Cartesian plane, symmetry and the construction of angles. This would appeal to most boys of this age as it is 'hands-on', not too abstract in concept and therefore relatively easier to master if given enough exposure to the work. The Grade 7 teacher (who taught all the Grade 7 learners in this study) also offered an extra lesson once a week, which was attended by approximately half of the learners. The self-efficacy of these learners would most likely be increased if they considered mastery to be achievable. This belief that they can excel in a task motivates learners to participate more (Liu & Koirala, 2009) and general motivation is heightened (Seaton et al., 2014). This motivation could affect other areas of the curriculum and, in so doing, improve mathematics performance.

5.2.2.5 Decrease in mean marks from Grade 7 to 9

The 8 percentage points decline in marks from Grade 7 to 8 is the largest for the M-set. This drop coincides with several events, such as the onset of puberty, the transition to high school and the introduction of new and challenging abstract mathematical concepts such as algebra. This result is consistent with the findings of Schunk and Pajares (2002), Breed and Virgona (cited in Callingham, 2010) and Martin and Steinbeck (2017). In the following paragraphs, these events and their possible influence on school performance are explored.

A child in the first few years of puberty experiences several physical, mental and psychological changes. This can be a stormy and challenging period for many individuals and affects their day-to-day responses to their environment. Testosterone levels increase in boys and they experience increased aggression, risk taking and sensation seeking (Peper & Dahl, 2013). Researchers, such as Arens et al. (2013) suggest that the transition to high school plays a more predominant, but negative, role in academic achievement than the concurrence of puberty and the transition to high school. Moreover, in the transition from primary to high school, the young adolescent faces additional challenges. These include a different and less-nurturing school set-up, the disruption of friendship circles, altered self-perceptions and the curriculum becoming vastly more abstract.

Relatedness

Many schools in South Africa are either a primary or a high school whereas the school in this study has the primary and high schools on the same property. However, when starting high school, the learners move to a new building with new teachers as well as a new playground area, which largely simulates the transition to a new school. The structure of the high school is more impersonal than that of the primary school. In addition, learners move to a different classroom to be taught by a different teacher for each subject during the day as opposed to being taught by only two or three teachers as was the case in the primary school. Teaching is more goal-oriented and there is pressure to complete the curriculum. Moreover, the high school teachers expect learners to work more independently than they previously did. Therefore, the high school structure is less nurturing and these learners' need for meaningful connections with peers and adults is unsettled (Barber & Olsen, 2004).

Peer pressure peaks in Grades 8 and 9 (Schunk & Pajares, 2002) while parental involvement usually decreases, causing these learners to form connections with their peers and non-familial adults (Eccles, 1999). Learners of this age have a heightened need for relatedness and connecting with others (Hazen et al., 2008; Pfeifer & Peake, 2012). Positive peer relationships are considered by early adolescents as one of the most significant facets of their lives and, when these learners transition to high school, having a sense of being accepted and fitting in with their peers is of great importance to them (Roseth, Johnson & Johnson, 2008). At the school in this study, the Grade 8 learners go from experiencing senior status in Grade 7 to being treated as juniors in the high school. Another significant change that takes place is the large intake of new learners in Grade 8. Each of the classes in Grade 8 increases by 10 to 12 learners. Friendship circles are disrupted as new boys are integrated into the classroom and playground set-ups. A large number of boys also move into the hostel in Grade 8, which means that there is even less parental involvement in homework than in Grade 7, adding to the challenge of coping academically.

Young adolescents are particularly susceptible to change (Baldwin & Hoffmann, 2002) and are influenced by positive and negative effects around them as they evaluate themselves in relation to others (Wigfield et al., 1991). When new learners arrive, many with superior academic skills that surpass those who were at the top of their class, some previously high-achieving learners may feel more vulnerable. Furthermore, their self-perceptions may be influenced negatively, and they may become discouraged. While there may be exceptions, where a learner is motivated by this challenge, most will experience a decrease in self-concept, self-efficacy and general motivation (Wigfield et al., 1991). This is where the teacher can play a critical role by using verbal persuasion to improve the learner's level of self-perception and by encouraging positive peer pressure to persuade learners to engage in the work. While these methods of heightening self-efficacy have an effect, they are not as powerful as mastery itself (Junqueira & Matoti, 2013).

If a learner is ostracized by a group because of newcomers or feels insecure for another reason, such as being bullied or underachieving in the classroom (Vaillancourt, deCatanzaro, Duku & Muir, cited in Peper & Dahl, 2013), they could experience a reduced self-concept during this transition (Eccles & Roeser, 2011), which Manning (2007) cites as an adaptive response to the overly optimistic perceptions of self, evident in primary school years. This decrease in self-concept and self-efficacy and, consequently, also in general motivation (Singh et al., 2002; Khan & Alam, 2015) affects how a learner approaches tasks and, as the new, more abstract curriculum offers challenges, the learner may not always be intrinsically motivated (Deci & Ryan, 2016). Instead, motivation will occur as a result of introjected regulation, where motivation is based on gaining the approval of peers or teachers or on avoiding punishment (Ryan & Deci, 2000a). However, this introjected regulation is not always positive and some learners, especially those who are battling with their schoolwork, may withdraw or act up to gain the approval of their classmates instead of working hard (Eccles, 1999). This need for the approval of peers and the intensified need to fit in while at the same time forming their own identity, plays a role in the way in which learners behave in the classroom and whether or not they choose to engage in an activity as well as the quality of that engagement (Anderman & Midgley, 1997; Pfeifer et al., 2009). This increases their awareness of what others think about them, making them more self-conscious. Therefore, they tend to ask fewer questions in class than they did in primary school, especially if their friends are not actively enquiring. Not obtaining timeous assistance when struggling contributes to a learner falling behind.

Another reality is the influence of digital devices on learners' sleeping patterns and study time. Adolescents need more sleep than those in late primary school, but often deprive themselves of sufficient sleep because of time spent on social media (fed by their need to connect with others). This, in turn, affects their concentration levels in the classroom. Aspects, such as an increased need for connecting with others and too little sleep (Hazen et al., 2008) add to the learners' overall tension in the classroom, influencing the way in which they respond to the academic demands of the school.

The prefrontal cortex of young adolescents is still maturing (Steinberg, 2005; Pfeifer et al., 2009) while their self-efficacy, which is an essential construct for academic achievement (Bouffard-Bouchard, 1990), is at a low point. Therefore, these two factors contribute to these learners not usually exhibiting prolonged self-regulation (Zimmerman, 1989). The gap created by changes in arousal and motivation early in puberty, before the frontal lobes have matured, increases these learners' vulnerability to difficulties in regulating emotions and behaviour (Steinberg, 2005). While learners in Grades 8 and 9 may set up goals, they struggle to remain committed to them. They may not fully realise what is required to accomplish their objectives and are easily distracted, thus not protecting these goals. In addition, they will often not manage the resources at their disposal effectively. They then lack direction and, too often, their engagement in tasks is half-hearted or erratic (Lemos, cited in Boekaerts, 1999).

Curriculum

When a learner reaches high school, a mathematical foundation has already been laid with some sections of the curriculum having been better mastered than others. From the beginning of the Grade 8 year abstract concepts are also introduced. It is well known that mathematical concepts build on one another and what is taught in earlier grades provides the foundation for Mathematics later on. Thus, how well a learner has mastered concepts in primary school affects how well he copes in high school. For example, in Grade 4 a learner is taught the commutative, associative and distributive properties of whole numbers. When learners are in the concrete operational stage, usually aged 7-12 years, they can, for example, apply the associative law and reverse their thinking by saying that $24 \div 4 = 6$ and $6 \times 4 = 24$. However, if a learner is not fully in this concrete operational stage and therefore not cognitively 'ready' in Grade 4 or 5 for the associative law being taught to him, he could miss extra practice and possibly fall behind in this concept. This will be especially problematic for a learner who finds Mathematics challenging. In Grades 8 and 9, this learner then experiences difficulty in applying this law when factorising and simplifying equations. Both low self-concept and self-efficacy result, preventing him from asking for help, and the negative cycle continues. Having a shaky foundation creates an even bigger problem when the application of concepts changes such as from the more concrete concepts to abstract algebra.

When exposed to algebra and the idea that a letter could represent a fraction, some learners experience natural number bias and, despite a general number sense, struggle with this abstract concept (Hewitt, 2014). These learners prefer to evade "messy" calculations when doing algebraic problem solving and try to avoid any remainders. This dilemma in algebra that a 'letter'/variable can be a number, part of a number or a range of numbers poses difficulties for several learners, too. In addition, Grade 8 learners have to deal with all the rules and laws associated with algebra. Exponents are used extensively and, if they have not mastered exponents in Grade 7, this could also present a problem in Grades 8 and 9.

A weak foundation in Grade 8 causes learners to struggle in Grade 9. Some of these learners may assume that they will be dropping Mathematics at the end of Grade 9 and are therefore not as motivated to put in the effort required (Chouinard & Roy, 2008). Nonetheless, parents often put pressure on learners to continue with Mathematics in Grade 10 as it is seen as an important subject that 'opens doors' and provides career opportunities. These learners then have to continue with Mathematics despite poor Grade 9 performance. This may account for (at least in part) another steep decline in mean Mathematics marks from Grade 9 to 10.

5.2.2.6 Increase in marks in Grade 12

The mean mark obtained by the M-set in Grade 11 is the lowest across all grades. Yet it is often the mark most frequently requested by universities when a learner first applies to a course. This places external pressure on learners to improve their lower, Grade 11 Mathematics mark. Learners begin to identify with the worth of studying their Mathematics and cooperating in class, not necessarily because they find it enjoyable, but rather because they recognise the benefit in doing so. Identified regulation motivates them to, for example, practise previous exam papers, attend extra classes and do their homework. Compared to early adolescence, where learners are still discovering taking ownership of their schoolwork, learners approaching the end of their schooling may have an increased level of self-regulation and autonomy as they develop skills, which enable them to engage in self-study, set goals for themselves regarding matric examination achievement, and develop aspiration for tertiary study. If this is the case, then learners who lack such skills and/or are less likely to need particular matric marks for their future education or employment opportunities should be less likely to develop self-regulation and autonomy in relation to their schoolwork in the last few years of schooling. Skills that enable engagement in self-study include reading comprehension, which is crucial for engagement with texts and thus reduced dependence on sources such as the teacher. Stott and Beelders (2019) found that only a small fraction of higher-achieving Senior Phase learners were able to read text typical of school science textbooks at levels above the frustration level. If this finding is generalisable to FET Phase learners' engagement with mathematical texts, the development of self-regulation and autonomy with maturation is likely to be retarded relative to learners who do possess the skills necessary for self-study.

The learners in this study received a high level of input from experienced teachers in Grades 11 and 12, with the learners' input and motivation to work probably being the greatest in Grade 12. Extra classes were mandatory in Grade 12, providing increased opportunity for mastery and thus contributing to improved self-efficacy. Learners were encouraged to set goals for matric, which could also have helped to improve self-efficacy (Bandura, cited in Liu & Koirala, 2009). The more self-efficacy and motivation to achieve higher marks increased, the more committed to their goals they would be (Bandura, 1993; 2009) and learners would tend to work more independently and self-regulate more (Hannula et al., 2016). These factors, together with a heightened sense of autonomy, probably played a role in the improvement of learners' Mathematics marks in Grade 12.

Some learners such as the top achievers in Mathematics may experience integrated regulation. They evaluate their identifications with their other values, for example, with studying hard to gain a high matric mark, and integrate these into their own life goals. At this level, motivation is self-regulated. These higher performers in Mathematics would generally also be more interested and confident in Mathematics and, as a result, more resilient when facing challenges, and hence achieve higher marks.

5.3 LONGITUDINAL PERFORMANCE OF THE MATHEMATICAL LITERACY SET

The ML-set consists of 160 learners. These learners took Mathematics at least to Grade 9, but definitely took Mathematical Literacy in Grade 12.

5.3.1 Results

5.3.1.1 Performance of the ML-set across eight cohorts

The mean marks by cohort (2009-2016) for the ML-set, as shown in Figure 5.4, ranged from 60% (cohort 2016) to 66% (cohort 2010). Thus, the range of the mean marks for the eight cohorts was 6%, indicating that when comparing cohorts, the marks were consistent.

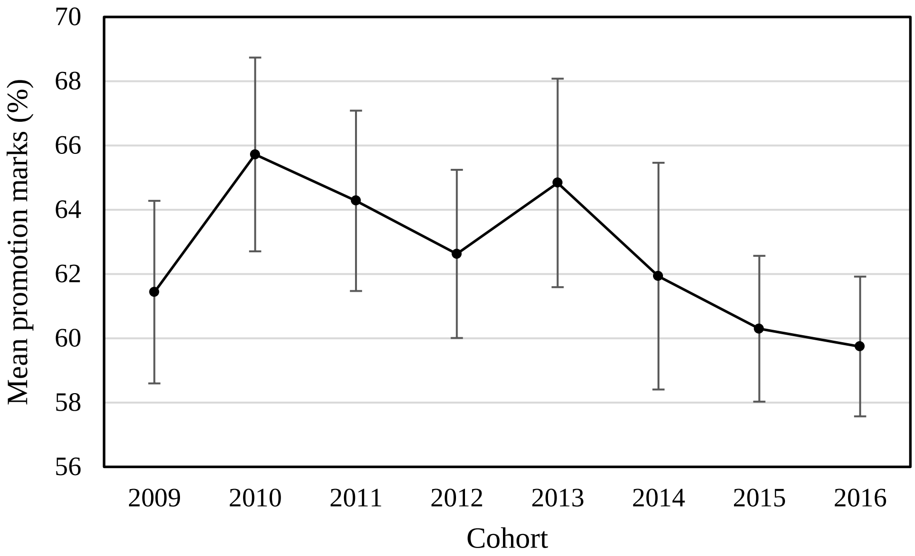

Figure 5.4: Mean promotion marks (%) and standard errors (SE) of all the learners in each of the eight cohorts (2009-2016) over their 12 years of mathematics instruction for the Mathematical Literacy set (ML-set)

5.3.1.2 Performance of the ML-set across phases

The mean marks of the phases for the ML-set showed variation from the Foundation to the Senior Phase. As shown in Figure 5.5 below, there was a very slight increase of 2 percentage points from the Foundation to the Intermediate Phase, after which there was a decrease of 7 percentage points in the Senior Phase. Once these learners changed to ML in Grade 10, the mean marks for the FET Phase showed an increase of 17 percentage points. The highest marks achieved for learners in the ML-set were in the FET Phase when they opted for Mathematical Literacy instead of Mathematics.

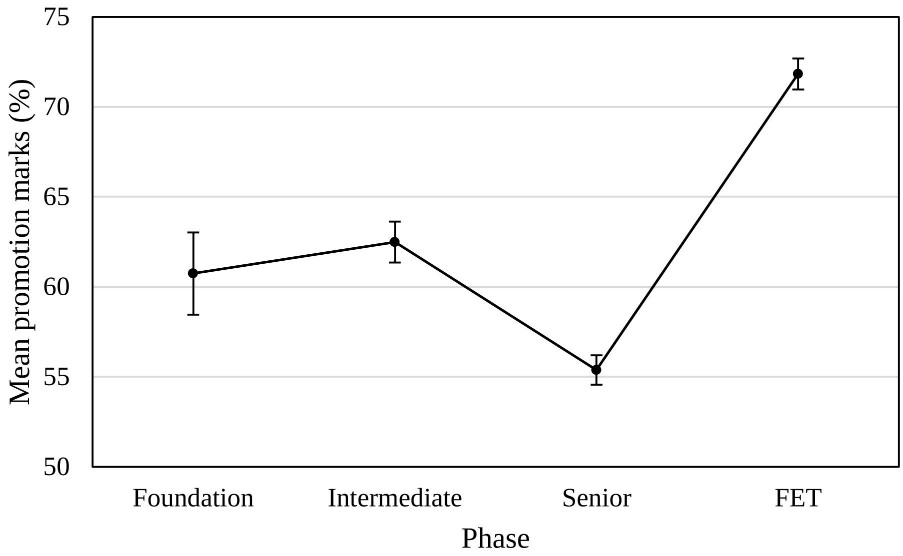

Figure 5.5: Mean promotion marks (%) and standard errors (SE) per phase of all the learners in each of the eight cohorts (2009-2016) for the Mathematical Literacy set (ML-set)

5.3.1.3 Performance of the ML-set across grades

As shown in Figure 5.6, the mean marks in the first six grades are somewhat stable with a range of 5%. There was a slight decrease of 4 percentage points from Grade 5 to 6, which was followed by an increase of 9 percentage points from 60% in Grade 6 to 69% in Grade 7. The highest Mathematics marks were achieved in Grade 7.

A very sharp decline in mean marks of 18 percentage points from Grade 7 to 8 is evident. This significant decrease in the ML-set's mean Mathematics marks is more than double the decrease evident between any other consecutive grades. Another drop (4 percentage points) follows from Grade 8 to 9. Thus, the total drop in mean marks from Grade 7 to 9 for the ML-set was 22 percentage points. After learners opted for Mathematical Literacy in the FET Phase, the mean mark for these learners increased from 47% for Mathematics in Grade 9 to 66% for Mathematical Literacy Grade 10. A slight increase of 4 percentage points occurred in Grade 11, with the mean increasing by a further 9 percentage points in Grade 12. The highest mark (79%) achieved for Mathematical Literacy by these learners was in Grade 12.

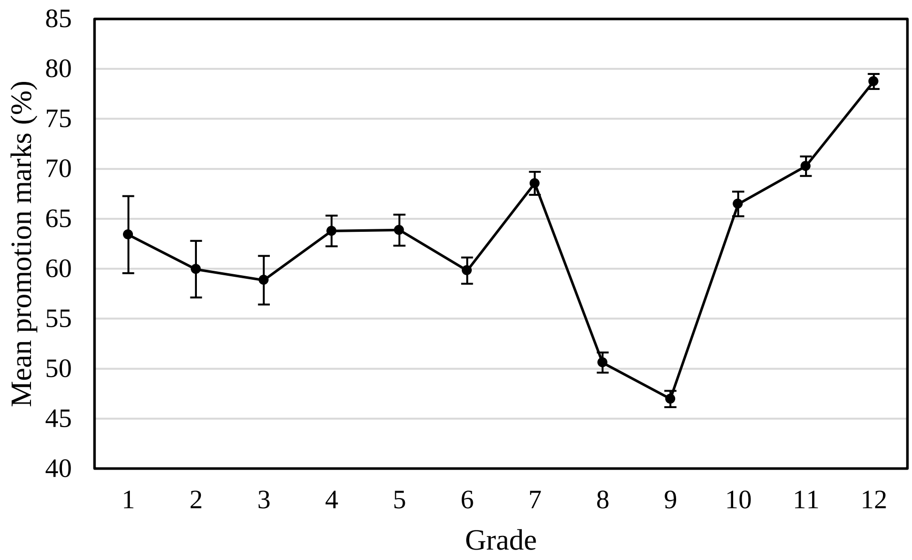

Figure 5.6: Mean promotion marks (%) and standard errors (SE) per grade of all the learners in each of the eights cohorts (2009-2016) for the Mathematical Literacy set (ML-set)

5.3.2 Discussion

There are some similarities between the performance of learners in the ML-set and those in the M-set. Where this occurs, to avoid repetition in this ML-set discussion, the reader is referred to Section 5.2.2 in the M-set discussion.

5.3.2.1 Stable mean marks from Grade 1 to 6 with a peak in Grade 7

The trend for the ML-set in the primary school is very similar to that for the M-set and possible reasons for the stability of marks in the Foundation Phase, an increase in marks from Grade 3 to 4, as well as the decline in marks in Grade 6 with the peak in Grade 7, were postulated in Section 5.2.2. The mean marks for each grade of the ML-set are consistently lower than those of the M-set. The maintenance of a gap from Grade 1 to 5 between underachievers and higher performers is supported by the findings of Princiotta, Flanagan and Germino-Hausken (2006). Although the researcher has no record of which learners received mathematical intervention, these findings are supported by Aubrey, Godfrey and Dahl (2006) who found that learners who begin schooling with a below-average mathematical competence remain low achievers for most, if not all, their schooling unless they receive effective intervention. Backlogs that can be traced back to early schooling are at the root of underachievement later on (Spaull & Kotze, 2015).

Young learners entering school have undeveloped self-perceptions about their academic abilities (Eccles, 1999). This is when self-efficacy is most malleable and should become more stable as they face tasks that are more challenging. While these learners do not ponder their own performance, they do start forming beliefs about their abilities (Gaskill & Hoy, 2002). As the learners from the ML-set progress through school, they continually experience being 'less-able' than their peers and, by the time they reach the end of primary school, they have a higher chance of believing that they are not as good as others at Mathematics. This low self-belief then has the potential to continue into high school.

5.3.2.2 Decrease in mean marks in Grades 8 and 9

Young adolescents not only have to deal with psychological and physiological changes because of puberty, they also experience several changes because of transitioning to high school. These changes, as discussed in the M-set discussion in Section 5.2.4, include disruption of peer groups, the classroom dynamic becoming more impersonal and goal-oriented, as well as the introduction to a more abstract form of mathematics, particularly in the form of algebra.

The learners in the ML-set not only have to deal with these issues but have also achieved consistently lower than their M-set peers. Moreover, when these learners reach Grade 8, they are often aware of their position in terms of the Mathematics classroom pecking order. The underperformance in primary school of the ML-set, compared to the M-set, is an indication of several mathematical skills not having been mastered by the ML-set. Mathematical concepts build on prior knowledge, and there are 'gaps' in these learners' skills base, hindering their mastery of new concepts. In the first term, when algebra is introduced, these learners' mathematics self-efficacy could drop even further than in primary school. Consequently, their self-concept is lowered as they compare themselves to others in their Grade. This is especially true for learners who are struggling to cope with the demands of the curriculum (Schunk & Pajares, 2002; Hannula et al., 2014). Therefore, when algebra is introduced, for example, if the concept of exponents and the associated laws have not been mastered, mathematics involving algebraic exponent laws will be more difficult for these learners. In algebra, learners are expected to manipulate abstract variables represented by letters while still trying to grasp what terms, such as 'squared' and 'cubed' really mean. Subsequently, in Grade 9, when the syllabus requires mastery of manipulation of more complex fractions and factorisation is taught, the learners who battled in Grade 8 may struggle even more, thus contributing to a further decline in their marks.

In primary school, fractions are taught, using positive integers and, later, in Grade 7, negative integers are introduced. In Grade 8, algebra and fractions merge and learners are required to apply their knowledge of these two areas simultaneously. This could create a huge challenge for learners who battled with these concepts in earlier grades. Mastery is a powerful source of self-efficacy (Gaskill & Hoy, 2002) and when these learners do not master, or struggle to master, concepts such as these, self-efficacy declines (Hannula et al., 2014) and a decrease in their self-concept follows. They may shy away from related activities, such as classwork and homework because they perceive these as threatening and they become discouraged. For some learners, anxiety and worrying about Mathematics creates an even bigger problem and lowers their self-efficacy even further (Pintrich & Schunk, 2002). If a learner is unsure that he will achieve some success in a task, he will be less motivated to attempt the task than one who is sure of what the outcome will be (Garon-Carrier et al., 2016). Therefore, to a certain extent, motivation, self-efficacy and self-concept predict these learners' avoidance of mathematics which, in turn, negatively influences long-term performance (Singh et al., 2002).

Another important aspect to consider is that certain habits and ways of interacting with the teacher and peers in the classroom and how the learner participates in class are also fairly well established when entering high school (Singh et al., 2002). There are learners who have learnt that it is safer not to try hard by, for example, leaving a task up until the last minute or not doing the homework properly. The reasoning used to justify this avoidant behaviour and lack of engagement in class may be the view that if these struggling learners do well with a small amount of effort then they are intelligent, and that if they do not do well, they can attribute it to not trying. This reasoning is often more acceptable for a weak learner than admitting that lack of ability was the cause of underperformance. They will rather attribute poor achievement to no effort than to lack of ability (Dweck, 2002). The lack of a strong mathematical foundation and subsequent negative approaches to mathematical tasks contribute to the marked decrease in performance from Grade 7 to 9.

5.3.2.3 Increase in mean marks from Grade 10 to 12

It is the researcher's experience that learners who only change to Mathematical Literacy in Grade 11 or 12 are usually stronger at Mathematics than those who opt for Mathematical Literacy in Grade 10 although many of them are also not achieving in Mathematics. Pressure from parents and learners wanting to pursue a post-matric course requiring Mathematics contribute to this trend. By contrast, learners who choose to do Mathematical Literacy as opposed to Mathematics in Grade 10 are generally those who have been failing Mathematics or struggling with it for several years.

The new Mathematical Literacy student in Grade 10 could experience insecurities about working with numbers, which may be an obstacle, especially initially. Consequently, it may take him a while to improve his Mathematical Literacy self-efficacy. (Here the learner would benefit from activities that incrementally build on his actual skills base in order to boost self-efficacy (Eccles, 1999).) When presented with a task, learners assess whether it has any value and determine the benefit of engaging in it. Much of the Mathematical Literacy curriculum is applicable to daily living and recognising the relevance of what they are being taught encourages learner involvement. They then take a course of action, using strategies and regulate their performance (Schunk & Zimmerman, cited in Hannula et al., 2016) As they perceive themselves as being mathematically more competent and are therefore more task-oriented (Guay, Chanel et al., 2010), marks improve.

In line with the Self-Determination Theory, the increase in marks over time from Grade 10 to 12 could be attributed to the presence of autonomous academic motivation. This motivation provides the reason for engaging in activities and the learners' efforts are more directed. Mathematical Literacy learners in Grade 12 at this school were supplied with many resources, such as a revision workbook covering the entire Grade 12 curriculum along with a continuous supply of exam papers with memos through which to work. The teacher also provided incentives such as allowing the use of earphones to listen to music while working through past exam papers in class. Even though learners were extrinsically motivated, there was evidence of engagement in self-regulation, at least among some of the learners when, for example, they requested additional revision activities. Self-regulation would have led to a greater degree of mastery, building confidence and thus increasing motivation. As these learners' levels of expectation with regard to efficacy increased due to a belief that hard work would result in achievement in higher marks, it is likely that self-regulation would also have increased, further improving their Mathematical Literacy marks. Liu and Koirala (2009), who researched Grade 10 learners, found that increased self-efficacy improved academic performance, thus explaining the year-on-year increase in mean marks in the final three years of schooling.

5.4 COMPARISON OF THE PERFORMANCE OF THE MATHEMATICS AND MATHEMATICAL LITERACY SETS

5.4.1 Results

5.4.1.1 Comparison of cohorts of the Mathematics and Mathematical Literacy sets

In Figure 5.7 below, it is evident that the trend is fairly consistent when comparing the mean marks of the ML-set with those of the M-set. On average, the ML-set performs 8 percentage points below the M-set.

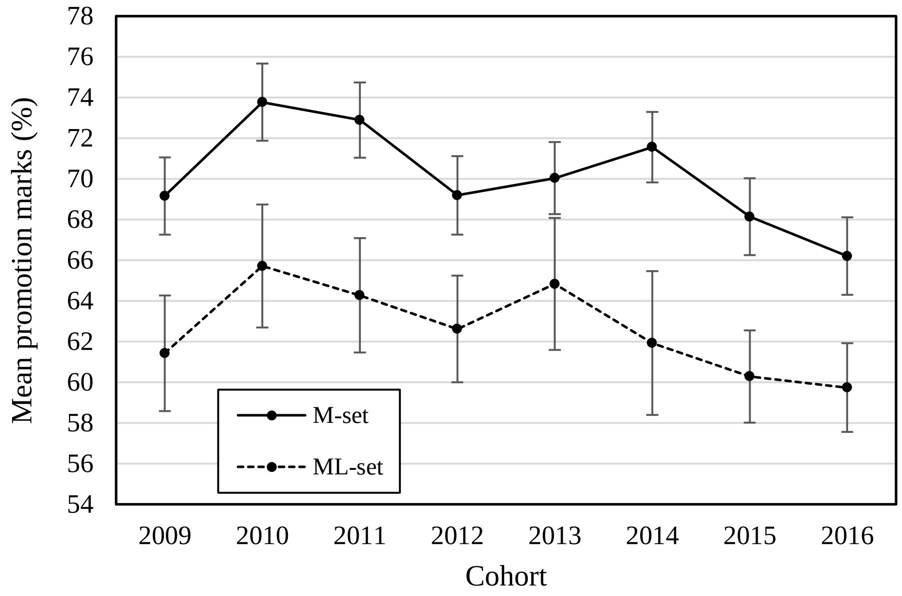

Figure 5.7: Mean marks (%) and standard errors (SE) of all the learners in each of the eight cohorts (2009-2016) over their 12 years of mathematics instruction for the Mathematics set (M-set) and the Mathematical Literacy set (ML-set)

5.4.1.2 Comparison of phases for the Mathematics and Mathematical Literacy sets

When comparing the changes across phases for the M- and ML-sets from the Foundation to the Intermediate Phase, Figure 5.8 below shows an increase in marks of 3% and 1% respectively. The average decline in marks for the M-set from the Intermediate to the Senior Phase is very slight (<1 percentage point) but is a substantial (7 percentage points) decrease in the ML-set. The gap between the two sets widens progressively from the Foundation Phase (10 percentage points difference) to the Senior Phase (19 percentage points difference). With the option of Mathematical Literacy in the FET Phase, these trends change. From the Senior to the FET Phase, the M-set has an average *drop* of 12 percentage points while the ML-set *increases* by 17 percentage points. The details of these differences will become clearer in the comparison of the sets by grade that follows.

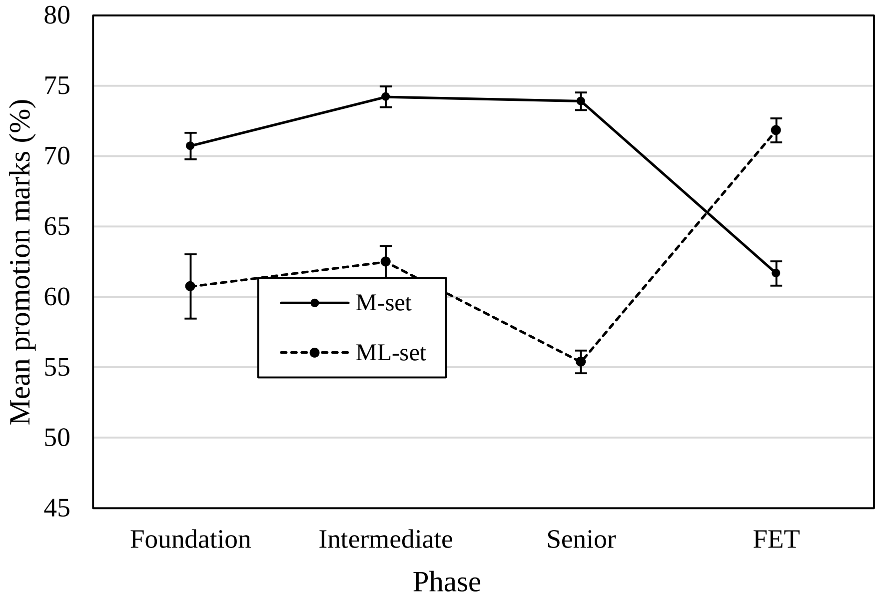

Figure 5.8: Mean marks (%) and standard errors (SE) per phase of all the learners in each of the eight cohorts (2009-2016) for the Mathematics set (M-set) and the Mathematical Literacy set (ML-set)

5.4.1.3 Comparison of the performance of the Mathematics and Mathematical Literacy sets by grade

In Figure 5.9, where the performance by grade between the two sets is compared, it is clear that while the general trend of decreasing and increasing of mean marks is similar in the two sets up until Grade 9, there is some variation when comparing grades within the phases. This is especially evident in the Senior Phase. There is also a significant difference between the performances of the two sets in the FET Phase.

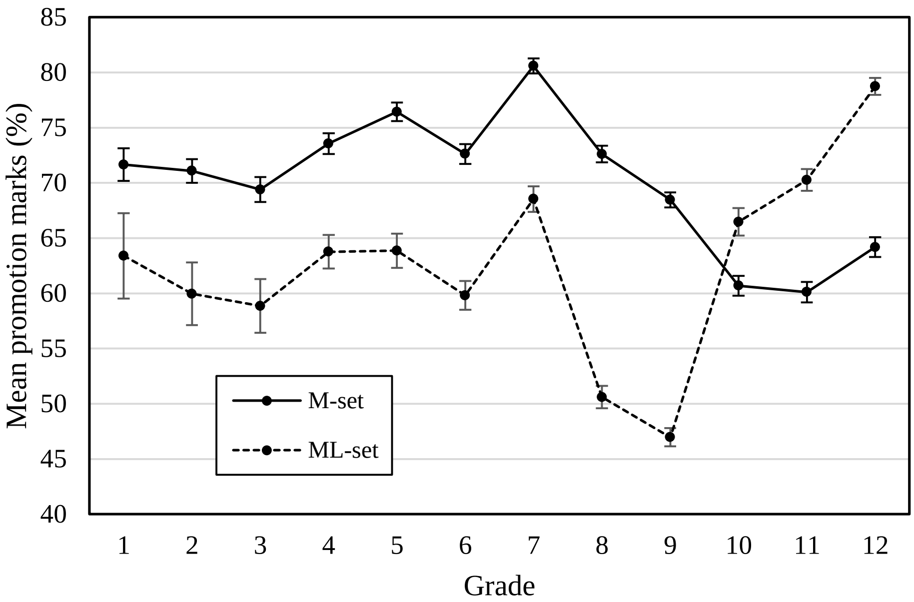

Figure 5.9: Mean marks (%) and standard errors (SE) per grade of all the learners in each of the eight cohorts (2009-2016) for the Mathematics set (M-set) and the Mathematical Literacy set (ML-set)

In Grade 1, the mean mark of the M-set is 8% higher than that of the ML-set, with mean marks of 72% and 63% respectively. The mean marks of the M-set in Grade 2 only drop by 1 percentage point while those of the ML-set declines by 3 percentage points, increasing the difference in mean marks of the two sets to 11 percentage points. From Grade 2 to 3, both sets experienced a slight decrease of 2 percentage points (M-set) and 1 percentage point (ML-set). Thus, the mean mark difference of 11% was maintained in Grade 3. Both sets had a decrease in mean marks from Grade 1 to 3, with the ML-set performing, on average, 10 percentage points below the M-set. This superior performance of the M-set is maintained throughout primary school and is discussed in the paragraph to follow.

Both sets showed an increase from Grade 3 to 5, and a decrease in Grade 6. In Grade 4, the M- and ML-sets' mean marks both increased by 5 percentage points. The M-set shows an increase of 2 percentage points from Grade 4 to 5, where the latter had no change in mean mark. In Grade 6, the mean marks fell by 4 percentage points for both the M- and ML-sets. This was followed by an increase in Grade 7, where the M-set increased by 8 percentage points and the ML-set by 9 percentage points. The mean mark across all grades for both sets was the highest in Grade 7. From Grade 5, the gap between the two sets widened and in

Grades 5, 6 and 7, on average, the ML-set performed 13% lower than the M-set. As seen in these results, the trends in the two groups up to Grade 7 are similar, with the performance of the ML-set being consistently lower than that of the M-set. In high school, however, the differences in these two sets become more marked.

The greatest decline in mean marks of both sets occurred from Grade 7 to 8, where the M-set showed a drop of 8 percentage points, while the ML-set showed a much larger decrease of 18 percentage points between these two grades. The change in mean marks from Grade 8 to 9 was less marked than from Grade 7 to 8, with the mean marks for both sets declining by 4 percentage points. As a result, a large difference between the mean marks of the two sets was maintained and the ML-set achieved 22% lower than the M-set in both Grades 8 and 9. This is considerably greater than the 8 percentage points difference in Grade 1.

At the end of Grade 9, those who continued with Mathematics had a decrease of 8 percentage points in their mean mark. There was a very small decline (<1 percentage point) in the mean Mathematics mark from Grade 10 to 11, which was followed by an upswing of 4 percentage points in Grade 12. The lowest mean Mathematics marks achieved by the M-set in any grade are in Grades 9 to 12, with the poorest mean mark across all grades being in Grade 11. The ML-set, on the other hand, showed a steady improvement in the FET Phase, with an overall increase of 13 percentage points from Grade 10 to 12, where the mean marks increased by 4 percentage points in Grade 11 and a further 9 percentage points in Grade 12. Thus, the ML-set achieved a mean mark of 47% for Mathematics in Grade 9 and matriculated with a mean mark of 79% for Mathematical Literacy in Grade 12, an increase of 32 percentage points and, potentially, four symbols higher on their school-leaving certificate.

5.4.2 Discussion

The trend of the two sets in primary school is very similar although the M-set's mean marks are consistently higher than those of the ML-set. However, after Grade 7, when learners enter high school, the differences become more marked. An explanation for possible factors causing these trends and variations in the sets follows.

5.4.2.1 Primary school

The majority of the learners who were in Grade 1 also attended the school's pre-school, and all had very similar input before starting formal schooling. However, the input from home is unknown and other factors that play a role, such as intelligence and exposure to mathematics could not be assessed. On entry into formal schooling, the M-set's mean mark is 8% higher than that of the ML-set. There is a reasonable possibility that this initial difference could be attributed to intelligence although there are other factors that contribute to a child's early school mathematics performance, such as the family's attitude towards mathematics and resources at home, which the researcher could not assess. The improvement in both sets from Grade 3 to 4 could be attributed, at least in part, to the input provided by the particular teachers concerned. It is well known at the school that the Grade 3 teacher was passionate about language. Over and above exposure to the LOLT from pre-school, this could also have contributed to improving the learners' LOLT. From Grade 4 to 5, the ML-set has no change in mean mark. This may be another indication of the ML-set struggling although the change in the M-set is also minimal.

While the performance of the two sets follows a similar trend throughout primary school, the gap between the two widens. The following explanation offers possible reasons for this. In Grade 1, these young learners tend to overrate their abilities and do not accurately compare themselves to others, with the result that their self-concept is not formed correctly (Manning, 2007). According to Pfeifer and Peake (2012), learners begin to compare themselves socially at about 7-9 years of age. They start noticing differences between those who are skilled at certain tasks and those who are less able. They do so by conducting self-evaluations and comparing themselves with others and, subsequently, they often experience an overall decrease in positive self-evaluations (Schunk & Pajares, 2002). As the ability to compare oneself with others improves, the relationship between behaviour and self-belief, self-efficacy and self-concept increase. The *accuracy* with which a learner rates his self-efficacy increases even more from Grade 5 to 8 (Zimmerman & Martinez-Pons, 1990). In addition, from Grade 1 (where self-perceptions are undeveloped) (Gaskill & Hoy, 2002) to high school, where increased competition and teachers paying less individual attention to learners' progress play a role, there is a *decline* in learners' self-perception of competence (Schunk & Pajares, 2002). It is possible that these self-perceptions affect learners' confidence and motivation. The weaker ML-set may exhibit reduced involvement in class activities compared to the stronger M-set. Some of these learners who feel incompetent may lose interest in Mathematics and need regular external regulation in the form of rewards or punishments to remain motivated (Guay, Chanel et al., 2010).

After the first years of schooling, the gap between the ML-set and the M-set widens as the ML-set increasingly struggles to cope. A possible reason for this weakening of the ML-set's performance compared to that of the M-set is the influence of the curriculum. In the Foundation Phase, the work is very concrete and a variety of visual and tactile aids form part of the learning process. This suits the more concrete ML-set type thinker. Another contributing factor is that learners are promoted based on their overall performance rather than on their mastery of specific subskills. This allows a learner to be promoted to the next grade despite the lack of certain basic skills in mathematics, with the implication that subsequent mastery will be jeopardised. (See Section 5.3.2 for the full discussion.)

5.4.2.2 Decline in Grades 8 and 9

On transitioning from Grade 7 in primary school to Grade 8 in high school, learners from both the M- and ML-sets experienced a sharp drop in mean marks. However, the latter set had a much greater decrease in mean marks (18 percentage points) compared to the 8 percentage points decline of the M-set. This decline is perpetuated to Grade 9 in both sets but is less marked than in Grade 8. Likely role players for the decline in each set, such as the need for relatedness, change in classroom set-up and the introduction of algebra were discussed in Sections 5.2.2 and 5.3.2. While it is impossible to determine, with certainty, the main reasons for this decline since the learners in this study were never interviewed or tested individually by the researcher, the two sets are compared by examining some of these potentially influential factors.

Due to the nature of a Mathematics curriculum, learners ideally should be competent in a specific area of Mathematics within that grade before moving on to more complex concepts in the following grade. However, in reality, this does not always occur. Learners proceed to the following grade provided that they have achieved the minimum requirement for passing. There are no minimum requirements for sub-sections of the Mathematics curriculum. Therefore, a learner could have virtually no grasp of certain concepts and still pass, moving on to the following grade. Any "gaps" in their knowledge are not necessarily filled before a new domain is taught. This could result in learners finding the following year more challenging than it would have been if they had a better grasp of the work taught in the previous grade.

The abstract concepts associated with algebra are encountered for the first time at the start of high school. These nonconcrete concepts, along with increased complexity of fractions and geometry, pose several challenges for the weaker, more concrete thinker who has not reached Piaget's formal operational stage. According to Kohlberg and Gilligan (cited in Papalia & Olds, 1981) and Kuhn, Langer, Kohlberg and Haan (cited in Huitt & Hummel, 2003), fewer than half of the learners in high school could be expected to have reached this stage of cognition. If this is the case then it would be accepted that a significant number of learners in this school's high school Mathematics classrooms will battle to grasp abstract relationships (Zhou & Brown, 2017). As new concepts build on those previously taught, and the likelihood of the ML-set's shaky initial grasp of the basics of algebra, fractions and geometry, subsequent topics could be even more taxing. The stronger M-set could have more learners in the formal operational stage and who are able to cope better with the increased level of abstractness in Mathematics because of this cognitive level of reasoning.

Whether learners struggle with or master these new concepts, their self-belief could potentially be altered. The literature shows a strong relationship between mathematics self-efficacy and performance in mathematics (Liu & Koirala, 2009) and, by the time a learner reaches early adolescence, the influence is evident. Learners entering high school have an increasingly accurate perception of their abilities. Nonetheless, this improved self-perception usually reveals a decline in academic self-efficacy because of the various stresses linked to the transition to high school (Pintrich & Schunk, cited in Schunk & Pajares, 2002). In turn, the learners in both sets of this study could have a reduced self-concept when entering high school. Schunk and Pajares (2002) found that this decline in self-efficacy and self-concept particularly applied to learners who were academically weaker. Anderman and Midgley (1997) assert that academically-weaker learners are more affected by the changes that occur as a result of the transition to high school than those who are academically stronger. Therefore, learners in the ML-set, who in Grades 8 and 9 are less academically able to deal with the increasing complexity of mathematical tasks, were potentially more susceptible to this decline in self-perception. As their motivation possibly declined, their mean marks dropped more drastically. Although self-efficacy has been shown in the literature to have an influence on motivation, there are learners who know that they have the ability to perform a task but choose not to participate to their full potential. This may be due to factors, such as the learner not seeing the point of the activity or being subjected to peer pressure because of the high need for a feeling of relatedness.

Toluk and Middleton (cited in Hannula et al., 2016) propose a repeated process in which motivation is regulated while, for example, solving a mathematical problem. Learners will begin with a task analysis and attach (or not attach) value to the activity. Once engaged, they draw on their resources such as previously-learnt skills and adjust their performance to achieve their desired (positive or negative) outcome. This will vary depending on the degree to which the learner is extrinsically or intrinsically motivated and the level on which he is able to self-regulate. The learner will then evaluate his performance. Hannula et al. (2016) maintain that when a learner has consistent experiences over an extended period, he will likely develop either a positive or a negative long-term stance towards Mathematics. Over several years (from Grade 1), the ML-set performed below the M-set and, while not all their mathematics experiences were negative, their general disposition towards the subject was likely to have been less positive than that of the M-set. The M-set would possibly have experienced lower levels of anxiety and shorter periods before mastery and, because their mean marks were higher, they probably received more praise, awards and positive feedback.

Learners in Grade 8 usually exhibit a higher level of self-regulation than younger children, but a lower level thereof than learners in the FET Phase (Zimmerman & Martinez-Pons, 1990). The self-efficacy of a young adolescent will influence his motivation because the self-efficacy determines the goals the learner sets (Eccles & Wigfield, 2002) as well as the level of effort he puts in and how determined he is, particularly when confronted with a difficult concept (Bandura, 2009). This, in turn, influences the degree of mastery in this subject, which then completes the cycle by altering the learner's mathematics self-efficacy (Zimmerman, 1989). This link between self-efficacy and performance is particularly strong for higher-performing learners (Liu & Koirala, 2009), especially males (Causapin, 2012) such as those in the M-set.

By contrast, the enjoyment of tasks and being intrinsically motivated to learn because it is fun wanes for the learners in the ML-set. If this is the case, they would reduce their efforts, be less productive and give up sooner (Bandura, 2009). Unless they see the value of the activity, these learners may not see the point of doing certain work and perform tasks reluctantly. This could apply to those who aim to change to Mathematical Literacy at the end of Grade 9 (Chouinard & Roy, 2008). From the researcher's teaching experience, many of these learners in Grades 8 and 9 do not understand the importance of learning algebra, for instance, hence their decline in motivation. This decline in motivation results in reduced performance and lower marks (Eccles, 1999). These learners would possibly need more prompting to work in class as their reliance on extrinsic motivation increases. For some ML-set learners, this negative cycle is only broken when they change to Mathematical Literacy.

The difference in the level of motivation and self-regulation affects the output of the two sets. This causes the M-set to not only outperform the ML-set, but also to have a smaller decrease in mean marks from Grade 7 to 9 than the ML-set.

5.4.2.3 Grades 10 to 12

In Grade 10, the M-set shows a decline in mean marks. Learners who have always excelled at Mathematics may continue to do well. However, there will be some who did not anticipate continuing with Mathematics after Grade 9 but have been coerced into taking it in Grade 10. Those learners who do not have a strong skills base, battle to master the more advanced mathematical problems. On the other hand, while the Grade 10 ML-set learners may be relieved at not having to deal with the abstract nature of algebra or complex geometry, some may still experience stress related to numbers due to their previous experiences with Mathematics. It may take a while for those who found Mathematics more challenging for many years to believe that they can do activities involving mathematical concepts. Due to the more concrete nature of the curriculum, they start to feel that they can master more of the work, thus improving their levels of self-efficacy and self-concept (Schunk & Pajares, 2002). A higher level of extrinsic motivation exhibited by learners who are achieving can be spurred on by the positive feedback from teachers and parents, resulting in an increased feeling of competency. As the learners in the ML-set gain self-efficacy and their feelings of competency improve, they could also experience an increased sense of autonomy as they take ownership of their mathematical literacy (Guay, Ratelle et al., 2010), resulting in a possible increase in self-regulation and enhanced performance (Ryan & Deci, 2000b).

Both the M- and ML-sets received additional input in the form of revision tasks. This provision of strategies and means for improving their skills increases their self-efficacy in these subjects. According to Eccles (1999), as learners realise that their abilities in a subject are due to incremental improvement, they believe that they can develop their skills even further. These higher levels of efficacy are maintained, especially if supported by significant adults.

There are learners who, in Grades 8 and 9, may have a high level of self-efficacy for doing a task, but when they do not see the worth of the task, they may not feel compelled (intrinsically or extrinsically) to do it (Eccles & Wigfield, 2002). Conversely, learners approaching the final years of their school career may feel external pressure to produce better results in order to be accepted for a university course or to pursue a career. This increased value attached to a subject causes the learner to study it with a higher level of enthusiasm even if he finds it uninteresting (Deci & Ryan, 2002). Although there was a slight improvement in the M-set's mean mark in Grade 12, valuing a subject and higher self-efficacy alone do not result in improved marks. It is necessary that resources, such as revision activities and contact sessions with the teacher, as well as previously-learned skills, are accessed (Causapin, 2012). The Mathematics teachers in the FET Phase, especially in Grades 11 and 12 at this school, provided resources to these learners, such as a mathematics clinic once a week and additional exam papers to revise their work. The ML-set were given a revision workbook as well as many opportunities in class to work through previous exam papers.

Learners' sense of autonomy could also be augmented and, as they experience progress, their self-efficacy is strengthened (Schunk & Pajares, 2002). Integrated regulation, the most advanced form of extrinsic motivation, which according to Harter (cited in Guay, Chanal et al., 2010), is only fully developed by late adolescence or even adulthood, may come into play. Some of the top achievers may even identify with valuing this subject in conjunction with their other life goals. Motivation, then, is self-regulated and the learner displays more interest and is more resilient (Deci & Ryan, 2002). This results in heightened academic performance.

5.5 CONCLUSION

As shown in this chapter, the mathematics performance of learners in both sets follows similar trends in primary school but differs greatly in high school. Several factors contributed to the increased vulnerability of both sets in the Senior Phase although the ML-set seemed to be more affected, showing a much greater decline in marks. Possible reasons for the marginal increase in marks for the M-set and the great improvement in marks in the ML-set in the FET Phase were proposed. The following chapter examines the degree to which earlier marks predict later marks, as well as the role this could play in subject choice for the FET Phase.

CHAPTER 6

RESULTS AND DISCUSSION OF REGRESSION ANALYSIS PREDICTING SUBSEQUENT GRADE MARKS BASED ON EARLIER GRADE MARKS

6.1 INTRODUCTION

Being able to predict learners' future performance, using earlier marks could be beneficial to teachers, parents and the learners themselves. This would potentially allow learners to receive intervention at an earlier stage of their schooling if needed. The predicted mark could also provide valuable assistance when learners have to select Mathematics or Mathematical Literacy at the end of Grade 9. Various researchers have focused on specific skills in earlier grades and how these competencies predict performance in subsequent grades (Duncan et al., 2007; Claessens et al., 2009; Hannula-Sormunen et al., 2015; Nguyen, et al., 2016). By contrast, in this study the precision with which a learner's average mark in an earlier grade predicts that for a later grade is determined for the investigated context. In using average marks in this way, it is important to bear in mind that an average mark is composed of marks achieved in several tests and examinations. Each of these assessments evaluates various concepts and procedures in the particular subject. Mathematics and Mathematical Literacy build on what has been mastered in previous years. However, that which has been mastered could differ from learner to learner despite their having similar average marks. In order to improve the predictive power of grade marks, further research is required.

Regression analysis was used to determine the precision with which mean marks in lower grades predict those in subsequent grades. The results in the Mathematics set (M-set) were more stable than the smaller, Mathematical Literacy (ML-set). Generally, the further apart the pair of grades, the less effective the prediction. This is because prediction far into the future (several years ahead) is usually less precise than prediction only one or two years ahead. Thus, the highest degree of efficacy in predicting final FET school grades is in using marks obtained in high school.

6.2 RESULTS

In Chapter 4, the background to the correlation and regression analyses was explained. The results of these analyses are clarified in this section. This will conclude with a focus on selected grades.

6.2.1 Correlation of Marks

The correlation estimates come from the Mixed Model for Repeated Measures (MMRM) analysis. The various correlations (r) of each grade with every other grade from Grade 1 to 12 for the M-set are shown in Table 6.1.

Table 6.1: Correlations (r) of grades (1-12) with one another for the Mathematics set (n=302)

Grade	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00	0.78	0.72	0.68	0.67	0.45	0.61	0.50	0.57	0.67	0.71	0.71
2	0.78	1.00	0.73	0.71	0.69	0.43	0.60	0.53	0.55	0.60	0.60	0.65
3	0.72	0.73	1.00	0.84	0.78	0.36	0.51	0.46	0.54	0.57	0.60	0.53
4	0.68	0.71	0.84	1.00	0.88	0.38	0.53	0.55	0.51	0.53	0.53	0.55
5	0.67	0.69	0.78	0.88	1.00	0.39	0.55	0.58	0.51	0.54	0.55	0.54
6	0.45	0.43	0.36	0.39	0.39	1.00	0.53	0.48	0.48	0.49	0.48	0.47
7	0.61	0.60	0.51	0.53	0.55	0.53	1.00	0.64	0.60	0.65	0.67	0.62
8	0.50	0.53	0.45	0.55	0.58	0.48	0.64	1.00	0.64	0.64	0.54	0.58
9	0.57	0.55	0.54	0.51	0.51	0.48	0.60	0.64	1.00	0.68	0.64	0.66
10	0.67	0.60	0,57	0.53	0.54	0.49	0.65	0.64	0.68	1.00	0.73	0.65
11	0.71	0.62	0.60	0.53	0.55	0.48	0.67	0.54	0.64	0.73	1.00	0.75
12	0.71	0.65	0.53	0.55	0.54	0.47	0.62	0.58	0.66	0.65	0.75	1.00

All correlations presented are significant ($p<0.05$).

In the following discussion, some strong correlations are considered, but the very modest correlation of Grade 6 with other grades is also discussed. The choice of which grades to focus on is not only based on the strength of the correlation but also on which grades in terms of a learner’s school career may be important. Grade 5 did not fall into these two groups but appears to be researched more regularly. Therefore, it is included in the discussion. All correlations in the present study were significant ($p<0.05$).

For primary school, attention is drawn to Grade 1, the first year of formal schooling, and to Grades 3 and 4, during which learners at this school experienced an increase in marks. Nationally, however, a decrease in mean marks occurred between these grades. In Grade 6, the learners in this study also experienced a decrease in mean marks, a phenomenon which demands further discussion.

The Grade 1 average mark correlates highly ($r= 0.67-0.78$) with most subsequent grades. Exceptions are Grades 6 to 9, where r ranges from 0.45 to 0.61, with Grade 6 being the lowest. Grade 1 not only has the highest correlation (0.78) with Grade 2, but also has a strong yet slightly lower correlation of 0.71 with both Grades 11 and 12. However, the latter two correlations may be biased because a large number of learners were in the school for Grade 12, but not for Grade 1. In this instance, the number of learners in Grade 1 who were also in the school in Grade 2 was 251. However, the number of learners who were in Grade 1 as well as in Grade 12 was only 148. The data for those learners who make up the difference (103) had to be imputed. Since this is a considerable proportion of the whole (41%), the degree of bias within the correlation between Grades 1 and 12 is considerable.

One of the strongest correlations (0.84) is between Grades 3 and 4. By contrast, a moderate to weak correlation was obtained between Grade 6 and all other grades. The highest correlation (0.53) that Grade 6 had was with Grade 7, while the lowest correlation of 0.36 is with Grade 3.

(For ease of reading, in this paragraph, the term ‘mark’ refers to the average mark attained by a learner in a grade.) In high school, the mark in Grade 8 has a moderately strong correlation of 0.64 with the marks in both Grades 9 and 10 but a slightly lower correlation of 0.54 with marks obtained in Grade 11, and a similar correlation of 0.58 in Grade 12. The correlation between Grades 9 and 10 marks is marginally higher (0.68) while the correlation of Grade 9 marks with those in Grade 11 is moderately strong (0.64). Marks obtained in Grade 9 predict those in Grade 12 with similar precision (0.66). Grade 10 marks correlate strongly (0.73) with those in Grade 11 and moderately strongly (0.65) with marks in Grade 12. The correlation between marks in Grades 11 and 12 is high (0.75). Hence, the correlations of all Mathematics marks in high school with marks in other high school grades are moderately strong to strong (0.54 to 0.75).

6.2.2 Prediction of Marks for the Mathematics Set

Data from the M- and ML-sets were used, and by multiple imputation (MI), missing values were imputed. Thus, 100 data sets were created for each set. Regression analyses were performed on these multiple imputed data sets. These, the regression coefficients, and their standard errors were averaged across the 100 imputed data sets and are reported below.

The regression results of the M-set grades that have stronger correlations and which are particularly important in learners' schooling, as well as other selected grades are shown in Table 6.2 below. The intercepts and standard errors (SE), as well as the gradients and SE, are provided. Two columns are included, where predicted marks based on obtaining 50% and 60% in earlier grades, have been calculated for illustration purposes. The correlation (r) for each of the grade pairs as previously discussed in Section 6.2.1 is also shown.

Table 6.2: Selected predictions of Mathematics marks for the Mathematics set (n=302), based on a learner obtaining 50% and 60% in earlier grades, using linear regression analysis results (intercept and gradient)

Earlier grade	Subsequent grade	Intercept (SE)	Gradient (SE)	Predicted mark (50%) (SE)	Predicted mark (60%) (SE)	Correlation (r)
1	2	42.71 (5.68)	0.40 (0.08)	63 (2.13)	67 (1.55)	0.78
1	5	56.90 (4.39)	0.28 (0.06)	71 (1.57)	73 (1.12)	0.67
1	11	34.61 (5.45)	0.36 (0.08)	53 (1.86)	56 (1.28)	0.71
1	12	42.26 (5.31)	0.31 (0.07)	58 (1.77)	61 (1.21)	0.71
3	4	45.61 (4.68)	0.40 (0.07)	65 (1.57)	69 (1.10)	0.84
7	8	4.56 (5.44)	0.85 (0.07)	47 (2.15)	55 (1.53)	0.64
8	9	19.33 (2.91)	0.67 (0.34)	53 (1.03)	60 (0.71)	0.64
8	10	-0.83 (4.47)	0.85 (0.06)	42 (1.56)	50 (1.07)	0.64
8	11	-0.25 (4.36)	0.83 (0.06)	41 (1.54)	50 (1.06)	0.54
8	12	5.53 (4.39)	0.81 (0.06)	46 (1.54)	54 (1.05)	0.58
9	10	-2.23 (4.29)	0.92 (0.06)	44 (1.35)	53 (0.89)	0.68
9	11	-5.83 (4.07)	0.97 (0.06)	42 (1.28)	52 (0.85)	0.64
9	12	1.55 (4.10)	0.92 (0.06)	47 (1.29)	57 (0.89)	0.66
10	12	21.80 (2.49)	0.70 (0.04)	57 (0.78)	64 (0.65)	0.65
11	12	13.59 (1.82)	0.84 (0.03)	56 (0.56)	64 (0.64)	0.75

All correlations presented are significant ($p<0.05$)

Grades 1 and 5 have been researched in several studies. As seen in Table 6.2, the M-set's mark in Grade 5, which is based on that attained in Grade 1, implies that if a learner obtains 60% in Grade 1, he can on average expect to obtain 74% in Grade 5. When predicting the level of achievement for the M-set in Grade 4, using the average mark obtained in Grade 3, an increase in the average mark is expected. As illustrated, should a learner obtain 60% in Grade 3, then he could expect to obtain 70% in Grade 4, suggesting an increase of 10 percentage points. In high school, if a learner obtains 60% in Grade 8, he can expect to obtain 54% in Grade 12.

6.2.3 Prediction of Marks for the Mathematical Literacy Set

Some grade pairs have been selected from the regression results of the ML-set and are shown in Table 6.3 that follows. It can be seen that the marks show an increase from Grade 1 to 5 and from Grade 3 to 4, but that the increase is lower than that of the M-set. A Grade 1 learner who obtains 60% in Grade 1 is likely to achieve 63% in Grade 5 whereas if 60% is obtained in Grade 3, then the learner is predicted on average to achieve 65% in Grade 4 (an improvement of 5 percentage points). In the Senior Phase, the mean marks of the ML-set learners decline drastically (18 percentage points) from Grade 7 to 8. Thus, if a learner obtained 60% in Grade 7, then he has a 64% possibility of attaining 47% in Mathematics in Grade 8 (a decline of 13 percentage points). However, if he is able to achieve 60% in Grade 8, he should obtain 51% in Grade 9, indicating a decrease of 9 percentage points.

Table 6.3: Selected predictions of Mathematics marks for the Mathematical Literacy set (n=160), based on a learner obtaining 50% and 60% in earlier grades, using linear regression analysis results (intercept and gradient)

Earlier grade	Subsequent grade	Intercept (SE)	Gradient (SE)	Predicted mark (50%)	Predicted mark (60%)	Correlation (r)
1	5	48.48 (5.07)	0.24 (0.08)	60 (1.95)	63 (1.69)	0.66
3	4	50.40 (6.34)	0.24 (0.10)	62 (2.06)	65 (1.88)	0.67
7	8	21.10 (7.82)	0.43 (0.11)	43 (2.30)	47 (1.40)	0.64
8	9	26.36 (3.42)	0.41 (0.07)	47 (0.84)	51 (1.05)	0.57

All correlations presented are significant ($p<0.05$)

Table 6.4: Predictions of Mathematical Literacy marks (Grades 10-12) for the Mathematical Literacy set (n=160), based on a learner obtaining 50% and 60% for Mathematics in earlier grades, using linear regression analysis results (intercept and gradient)

Earlier grade	Subsequent grade	Intercept (SE)	Gradient (SE)	Predicted mark (50%) (SE)	Predicted mark (60%) (SE)	Correlation (r)
8	10	43.73 (4.83)	0.45 (0.10)	66 (1.25)	71 (1.68)	0.57
	11	51.49 (4.00)	0.36 (0.08)	70 (0.92)	73 (1.22)	0.48
	12	60.47 (2.87)	0.36 (0.06)	78 (0.67)	82 (0.86)	0.53
9	10	51.99 (5.32)	0.31 (0.12)	67 (1.39)	71 (2.16)	0.73
	11	54.83 (4.17)	0.32 (0.09)	71 (0.98)	74 (1.49)	0.55
	12	58.23 (2.93)	0.43 (0.06)	80 (0.67)	84 (1.01)	0.80

All correlations presented are significant ($p<0.05$)

In Table 6.4, the predicted Mathematical Literacy marks for learners from the ML-set based on their achieving 50% and 60% for Mathematics in Grades 8 and 9 are shown. Grade 8 predicts Grades 10 to 12 with a moderate correlation (r = 0.48-0.57) whereas Grade 9 has a strong correlation (0.73) with Grade 10 and an even stronger correlation (0.80) with Grade 12. Should a learner achieve 50% in Grade 8 or 9, his Mathematical Literacy mark in any grade would probably be higher than 65% in Grade 10 and, by Grade 12, it could be as high as 78% or 80%. If 60% was achieved for Mathematics, a Mathematical Literacy learner could achieve above 70% in Grades 10 and 11, with a mark of over 80% in Grade 12. This would give him an "A" symbol on his matric certificate.

6.3 DISCUSSION

6.3.1 Grades 1 and 5

As illustrated in Table 6.2, the results of the regression analysis show that there is an increase in mean marks from Grade 1 to 5. A learner who attains an average mark of 50% in Grade 1 has a 66% chance of on average obtaining 60% in Grade 5. Likewise, an average mark of 60% in Grade 1 means that a learner would achieve an average mark of 63% in Grade 5. Determining the exact subskills that allow a learner to improve on his Grade 1 marks in Grade 5 is outside the parameters of the present study. However, these results, where there is a moderate to strong correlation between Grades 1 and 5 (0.66), confirm the findings of Claessens et al. (2009), Geary et al. (2013), and Hannula-Sormunen et al., (2015) that Grade 1 mathematics skills do predict mathematics performance in Grade 5.

It is possible that the Grade 1 learners in the present study experienced positive feedback right at the start of their schooling or even earlier in pre-school. These positive messages would have fed their self-efficacy and self-concept (Hannula et al., 2014). The learners would then potentially persevere more and tend not to give up easily (Bandura, 1977), increasing the possibility of mastering a concept. Since mathematical concepts build on one another, these learners go from strength to strength, maintaining a higher trajectory. They also remain in the upper achieving group in the grade. Similarly, it is also possible that a learner who receives negative feedback will not put in as much effort, reducing an increase in mathematical knowledge so that a lower trajectory is maintained across his schooling. Such a situation would also contribute to the correlations between grades being strong.

6.3.2 Grades 3 and 4

Most learners transitioning from Grade 3 to 4 in the present study show an increase in average marks from one grade to the next. For example, if an M-set learner attains an average mark of 60% in Grade 3 then it is predicted that he will obtain an average mark of 70% in Grade 4 (see Table 6.2). A ML-set learner who obtains an average mark of 60% in Grade 3 is likely (r=0.67) to achieve 65% in Grade 4 (see Table 6.3). Although the increase for the M-set (10%) is greater than for the ML-set (5%), the mean marks of both sets increase from Grade 3 to 4. Additional calculations reveal that the predicted mark for both the M- and ML-sets is similar if learners achieve 40% in Grade 3. The predicted mean mark for the former set's learners in Grade 4 is 62% and for the learners in the latter set, 60%. Learners achieving at the upper end, for example an M-set learner who attains 80% in Grade 3, will probably have a decrease in mean marks to 77% in the following grade whereas the decline for an ML-set learner is greater, down to 69%. This highlights the fact that while a previous grade's marks may be used to predict later marks, this relationship is not as straightforward as: x% mark in one grade will mean y% in a later grade. It also depends on what the individual actually achieves in the earlier grade.

6.3.3 Grades 8 to 12

On entry to high school, new concepts in algebra and geometry are introduced, making Grade 8 a crucial year for establishing a solid skills foundation. As previously discussed in Sections 5.2 and 5.3, marks decrease from Grade 7 to 8 and, because of the importance of strong scaffolding in a subject such as Mathematics, this could have a negative effect on subsequent grades. According to the regression results in Table 6.2, if an M-set learner attains 50% in Grade 8 then, based on the estimated distribution of marks of learners with 50% in Grade 8, there is a 64% probability that this individual will obtain a mark of at least 53% (±1.03) (an increase of 3 percentage points) in Grade 9 and 42% (1.56) (a decrease of 8 percentage points) in Grade 10. However, if a learner from the same set attains 60% in Grade

8 then there is a 64% probability that this individual will obtain a mark of at least 60% (±0.71)(unchanged) in Grade 9 and 50% (±1.07) in Grade 10. This confirms the complexity of using earlier grade marks to predict subsequent grade marks.

At the end of Grade 9, learners who are weaker in Mathematics may opt to continue with Mathematics in Grade 10 in the hope that their Mathematics marks will improve or remain the same and that they will be able to matriculate with Mathematics. Some of these learners then change their subject choice to Mathematical Literacy in Grade 11 or 12. An additional comparison was made between the mean Mathematics mark achieved in Grade 9 and that achieved in Grade 10 for *all* learners who continued with Mathematics in Grade 10 (n=347), 45 of whom later changed to Mathematical Literacy. This was done in order to determine how widespread the decrease in the Mathematics mark was from Grade 9 to 10 on the individual level for this complete group of learners. In this additional comparison, it was found that 81% of learners' Mathematics marks lowered from Grade 9 to 10 and that the average decrease was 8 percentage points.

The ability to predict an average mark in subsequent grades, such as in Grade 10 based on their Grades 8 and 9 marks is useful as it provides parents and learners with a 'glimpse into the future', without their perhaps spending time with the incorrect choice between Mathematics and Mathematical Literacy. Some questions posed by parents when their child has to choose between Mathematics and Mathematical Literacy include: "If my child is getting 50% in Grade 9, what mark could he expect in Grade 12?" or "How much better would his mark be if Mathematical Literacy was chosen instead?" Table 6.5 below provides a visual comparison between predicted Mathematics and Mathematical Literacy marks in Grades 10, 11 and 12 for learners who have a mean mark of 60% in Grade 8. A similar comparison is given for those who obtain 60% in Grade 9. Reddy, Van der Berg et al. (2012) conducted a study comparing learners' Grade 8 mathematics performance in the Trend in Mathematics and Science Study (TIMSS) with their final Grade 12 Mathematics results. Grade 8 learners from middle-class schools were compared to those from poorer schools and it was found that the Grade 8 marks of learners in the wealthier schools were a moderately strong predictor of marks in Grade 12 while those from poorer schools were not as strong (correlations are not provided in Reddy, Van der Berg et al., 2012). In the present study, a similar result (moderately strong) was obtained with a correlation of 0.58. Since Grades 8 and 9 marks are usually used to decide whether a learner should continue with Mathematics, these grades will be the focus in the paragraphs to follow.

Table 6.5: Comparison of predicted Mathematics and Mathematical Literacy marks in subsequent grades based on a learner obtaining 60% in Grade 8 or 9

Earlier grade	Subsequent grade	Predicted Mathematics mark (%) (SE)	Predicted Mathematical Literacy mark (%) (SE)
8	10	50 (1.07)	71 (1.68)
8	11	50 (1.06)	74 (1.22)
8	12	54 (1.05)	82 (0.86)
9	10	53 (0.89)	71 (2.16)
9	11	52 (0.85)	74 (1.49)
9	12	57 (0.86)	84 (1.01)

In Table 6.6, the predicted marks for Mathematics and Mathematical Literacy for learners achieving 80% for Mathematics in Grades 8 and 9 are given. If 80% was attained in Grade 8 then the predicted Mathematics mark in Grade 12 is 70%, a decrease of 10 percentage points. On the contrary, if Mathematical Literacy was chosen, an improvement of 13 percentage points by Grade 12 is predicted.

Table 6.6: Comparison of predicted Mathematics and Mathematical Literacy marks in subsequent grades based on a learner obtaining 80% in Grade 8 or 9

Earlier grade	Subsequent grade	Predicted Mathematics mark (%)	Predicted Mathematical Literacy mark (%)
8	10	67	80
8	11	66	80
8	12	70	89
9	10	71	77
9	11	72	80
9	12	75	93

Many learners achieve far below 80% in Grade 9. Thus, a discussion on the scenario in which a learner obtains 50% or less for Grade 9 follows. As seen in Table 6.7, a learner who achieves an average Mathematics mark of 50% in Grade 9 is predicted to obtain 49% for Mathematics as opposed to 67% for Mathematical Literacy in Grade 10. This is a difference of 18 percentage points. In Grade 11, the predicted average mark for Mathematics declines further to 43% while, for Mathematical Literacy, it increases to 71%. In Grade 12, there is an increase in the average mark for both sets, but the Mathematics average mark is still under 50% while the Mathematical Literacy mark is 80%.

Table 6.7: Comparison of predicted Mathematics and Mathematical Literacy marks in subsequent grades based on a learner obtaining 50% in Grade 8 or 9

Earlier grade	Subsequent grade	Predicted Mathematics mark (%)	Predicted Mathematical Literacy mark (%)
8	10	42	66
8	11	41	69
8	12	46	78
9	10	49	67
9	11	43	71
9	12	48	80

A consequence is that a hypothetical learner at this school could follow one of these trends in taking either Mathematics or Mathematical Literacy. The former choice would result in his not qualifying for his Mathematics mark to be counted among his designated subjects since it fails the 50% minimum requirement. In contrast, should he have chosen Mathematical Literacy, his Mathematics Literacy mark would be higher than this 50% minimum, qualifying its inclusion among his designated subjects. A learner needs four designated subjects to qualify for university entrance. Furthermore, if he took Mathematics, there would, according to the University of the Free State's website, also be a difference of four points fewer towards an Admission Point Score (APS). A Mathematics mark of 40-49% earns three points as opposed to a Mathematical Literacy mark of 80%, earning seven points. Simkins (2010) suggests that it is wasteful if learners who could pass Mathematics with 50% opt for Mathematical Literacy. This would depend on the perspective taken because firstly, there is no guarantee that a 'borderline' learner will achieve above and not below 50% in Mathematics. Both the lack of enough designated subjects and the lower APS could prevent university entrance. Secondly, for a weaker learner who has no intention of following a Mathematics-related course after school, Mathematical Literacy may prove to be more beneficial for his future, given its more practical focus. This means that the same learner, with a Grade 9 mark of 50%, could have two different outcomes at the end of matric based on subject choice.

Table 6.8: Comparison of predicted Mathematics and Mathematical Literacy marks in subsequent grades based on a learner obtaining 40% in Grade 8 or 9

Earlier grade	Subsequent grade	Predicted Mathematics mark (%)	Predicted Mathematical Literacy mark (%)
8	10	33	62
8	11	33	66
8	12	38	75
9	10	35	64
9	11	33	68
9	12	38	75

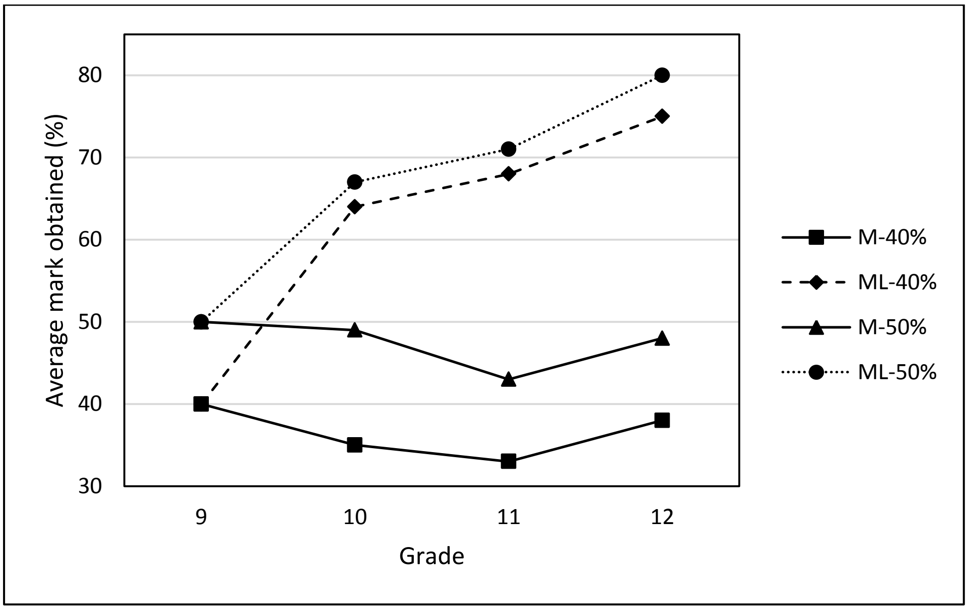

Figure 6.1: Comparison between predicted Mathematics (M) and Mathematical Literacy (ML) marks for a learner who obtains 40% or 50% in Grade 9

A comparison of the predicted mark for both sets, based on a learner obtaining 40% in Grades 8 and 9, is shown in Table 6.8. In Figure 6.1, the information in Tables 6.7 and 6.8

are combined to provide a comparison between predicted Mathematics and Mathematical Literacy marks for a learner who obtains 40% or 50% for Mathematics in Grade 9. If a learner attains 50% in Grade 9, his Grade 12 mark for Mathematics is predicted to be 48% while his Mathematical Literacy mark could be 80%. For a learner achieving 40%, the Mathematics outcome is bleak as the average mark predicted for Grade 10 Mathematics is 35%. This translates into a mere 38% in Grade 12 whereas for Mathematical Literacy, he could achieve 64% in Grade 10 and 75% in his final year at school. In this way, enabling a learner, teacher or parent to predict the potential outcome of studying Mathematics or Mathematical Literacy could facilitate improved subject choice decisions.

6.4 CONCLUSION

The present study showed that it is possible to predict, with a moderate to strong degree of precision, the average mark that a learner could expect to attain in most subsequent grades. The importance of making the correct subject choice between Mathematics and Mathematical Literacy was discussed. Moreover, it was illustrated how the outcome in Grade 12 for learners with a Grade 9 mark of 50% or lower, especially, can be vastly different, depending on which of the two subjects is selected. The high practical component of Mathematical Literacy benefits learners who have not yet reached Piaget's formal operational stage in that mastery is more probable and, consequently, self-efficacy and self-concept are heightened, hence the increase in marks. Therefore, it is in the best interest of these weaker learners to take Mathematical Literacy instead of Mathematics.

The correlation between Grades 1 and 5 was consistent with other research (Hannula-Sormunen et al., 2015). In Grades 3 and 4, the predicted Grade 4 grade mark is higher than that achieved in Grade 3, where the LOLT could be a contributing factor. The present study has also highlighted the importance of early learning being of the highest standard if a learner is to achieve at a high level later in his school career.

CHAPTER 7

CONCLUSION

7.1 INTRODUCTION

The aim of this research was to determine the longitudinal mathematics performance of learners from Grade 1 to 12. As a result, the following research questions guided this study:

Primary research question: What is the longitudinal profile of mathematics performance of boys attending a South African ex-Model C, single-gender school?

Secondary research questions:

- How does mathematics performance change through the course of schooling for learners who take Mathematics to Grade 12 as opposed to that of those who take Mathematical Literacy?
- How effectively does learners' mathematics performance in lower grades predict their mathematics performance in higher grades?

An ex-Model C boys' school was used to conduct this case study. Eight consecutive cohorts were identified, with the final cohort matriculating in 2016. The annual promotion marks achieved by each learner while attending this school were retrieved from the South African School Administration and Management System (SA-SAMS) and the school's databases. The data were analysed, fitting a Mixed Model for Repeated Measures (MMRM). The MMRM was fitted, using Restricted Maximum Likelihood (REML), with fixed effects of cohort, grade and grade within a cohort. The MMRM fitted an unstructured (UN) covariance matrix to the 12 repeated measurements obtained from the Mathematics and Mathematical Literacy promotion marks of students from 1998 to 2016. Two sets, a Mathematics set (M-set) (n=302) and Mathematical Literacy set (ML-set) (n=160), were determined based on the subject chosen for Grade 12 (See Chapter 4).

Very clear patterns emerged from the data analysis, and similarities as well as differences in performance in the two sets were observed. Possible reasons for the results were postulated, using research in the literature, Ryan and Deci's Self-Determination Theory (SDT) and Piaget's Cognitive Theory (see Sections 3.2 and 3.3). An investigation into the effectiveness of using earlier marks to predict subsequent marks also revealed interesting and potentially useful results (See Chapters 5 and 6). The following sections summarise the findings of this study and explain the assertions related to, and implications of, the findings.

7.2 SUMMARY OF KNOWLEDGE CLAIMS

The following were the most notable findings:

- The Mathematics set consistently performed better than the Mathematical Literacy set throughout primary school, with an average difference of 10% in mean marks;
- Contrary to national statistics, the mean marks improved from Grade 3 to 4;
- Grade 6 had the lowest correlations with any other grade and the greatest decline in mean Mathematics marks in primary school;
- The Senior Phase is a period in which learners are particularly vulnerable and a substantial decline in mean marks for both sets occurred from Grade 7 to 9; and
- The Mathematical Literacy set's mean marks increased year-on-year, while those of the Mathematics set continued to decline in Grades 10 and 11, with a slight improvement in Grade 12.

7.3 APPROPRIATENESS OF THE SELF-DETERMINATION THEORY IN EXPLAINING TRENDS

The Self-Determination Theory has been applied successfully to explain the results, including the trends observed over time. Other research on mathematics and school performance confirms the applicability of this theory to achievement (Guay, Ratelle et al., 2010; Guay, Chanal, et al., 2010; Rodgers et al., 2014; Ryan & Deci, 2016). The researcher could not interview learners or teachers directly to find out more precisely which factors played a role in the learners' level of motivation at various stages of their mathematics schooling. Therefore, the explanations are generalised in nature.

7.4 THE IMPLICATIONS OF LEARNERS' MATHEMATICS PERFORMANCE OVER 12 YEARS OF SCHOOLING

The first part of this discussion is dedicated to the implications of the mathematics performance of learners from Grade 1 through to Grade 12, after which the effectiveness of using earlier marks to predict later marks is elucidated.

7.4.1 M-Set Consistently Achieving above the ML-Set: The Importance of a Strong Start to Formal Schooling

Learners tended to sustain their trajectory throughout their school career so that those who started their schooling in a "stronger" position maintained their superior standing, which confirms the findings of Reddy, Van der Berg et al. (2012). This suggests that a high-quality early childhood education is beneficial for a learner to get off to the best possible start in Grade 1 in order to perform to his full potential throughout his schooling. Currently, in South Africa, Grade 12 results receive a great deal of attention, with an enormous amount of energy being spent on assisting these educators and learners (Spaull & Kotze, 2015). It is likely that by building young learners' self-efficacy and self-concept through positive feedback, they will be more motivated to persevere when doing mathematical problems. This should increase their gains in mathematics, which have been shown to predict a higher level of performance later in their schooling (Watts et al., 2014). The value of early gains, together with the clear pattern of mathematics performance over time, emphasise that if learners achieved at a higher level on entry to school, there could be an improvement in their mathematics performance in the long run and, ultimately, also in Grade 12.

The consistency of one set performing poorer than the other throughout their schooling does imply that learners who will potentially take Mathematical Literacy in the Further Education and Training (FET) Phase could be identified early on in their school career. This could assist the DBE in targeting this group for inclusion in interventions early on in their schooling and thus conceivably increase the number of learners taking Mathematics.

7.4.2 Grades 3 to 4: Possible Impact of Early Exposure to LOLT

An interesting finding was that in the transition from Grade 3 to 4, learners had an increase in mean marks, which is contrary to those of the national population (Graven, 2016). One difference between the learners in this study and the majority of the population is that the former were exposed to the Language of Learning and Teaching (LOLT) used in Grade 4 from pre-school. It is likely that these learners had an advantage over those who had to change to a language, which was not their mother-tongue in Grade 4 when the work is also more complex. Allowing pre-school and Foundation Phase learners to be taught in the same language as that used in Grade 4 may assist in raising the Grade 4 performance relative to that in Grade 3. However, this does pose other challenges for these learners in the lower grades where they may not yet understand the LOLT at all. Communities may also object to their school beginners not being taught in their mother-tongue.

7.4.3 Grade 6: Challenge of Applying Several Procedures and Concepts Simultaneously

Surprisingly, the Grade 6 mean marks consistently had the lowest correlation with those of other grades. Moreover, the largest decline in mean marks in the primary school occurred in Grade 6. On examination of the Grade 6 curriculum used and the types of mathematical problems that need to be mastered in this grade, it is evident that many of these sums require several concepts and procedures to be applied simultaneously. Thus, it would benefit learners if, in preparation for Grade 6, their competency regarding concepts, such as times tables, fractions and division could be at a higher level of mastery and if they had increased exposure to mathematical problems involving more than one procedure in Grades 4 and 5. Reinforcing these skills before Grade 6 could enhance their abilities and self-efficacy when, for example, applying various methods in the same sum in Grade 6.

7.4.4 Grades 7 to 9: A Vulnerable Period with Dismal Results

The Senior Phase is a period in which early adolescents face several changes and they appear to be more vulnerable because of these. It is evident that during this phase, when learners transition to high school and the curriculum also becomes more abstract, the greatest decline in mean marks for both sets occurs. These learners also have a greater need for relatedness and connection to their peers and non-parental significant adults (see Sections 2.7 and 2.8).

The changes in the Senior Phase, accompanied by the greatest decrease in mean marks, implies that learners need ongoing and, possibly, increased support and guidance in the transition to high school and throughout the Senior Phase (Parker, 2010). Learners in the FET Phase, especially Grades 11 and 12, tend to be the focus of the DBE while the Senior Phase learners do not receive the same level of support. Any difficulties experienced with mathematical concepts and procedures in earlier grades appear to compound over time, culminating in a low level of mastery of mathematics in Grades 8 and 9. Based on the fact that earlier grades affect the level of performance in later grades, learners in the Senior Phase need a high level of input and guidance if the Grade 12 results are to improve. Educators and policy makers have a great challenge in assisting learners to bridge the gap between the more concrete primary Mathematics and the abstract concepts taught in high school while also being sensitive to learners' affective needs.

These learners' psychological needs must also be met for them to internalise the value of the subject and to develop a sense of ownership of what is happening in the classroom (Ryan & Deci, 2016). Educators would do well to assist these young adolescents by increasing feelings of relatedness, perceived competence and a sense of autonomy to enhance learner engagement (Ryan & Deci, 2000a) and, in so doing, improve marks. Also, increasing learners' sense of autonomy and perception of competency would help them to 'buy in' to what is taking place in the classroom. Instead of extrinsic motivation guided by external rewards and punishments predominantly being used to motivate, these learners should be encouraged to develop a conscious valuing of the subject so that it gains personal importance to them. As identified and integrated regulation increase, learners' autonomous motivation also increases.

7.4.5 The Increase in ML Marks: A Case for Increasing Self-Efficacy and Self-Concept

Mathematical Literacy learners' mean marks increased year-on-year until Grade 12. It is likely that these learners' mathematics self-efficacy and self-concept were initially lower, but as they realised that they were able to master the Mathematical Literacy content, these self-perceptions improved. The Mathematical Literacy teachers who taught the learners in this study, all of whom are known to the researcher, encouraged feelings of relatedness, perceived competence and a sense of autonomy in the classroom. This implies that it is possible for teachers to strengthen these self-perceptions and boost self-efficacy and self-concept which, in turn, yield higher marks. Mathematical Literacy is also an easier subject that requires more concrete and less abstract thinking and it is likely that this also contributed to the improvement in learners' marks from Grade 9 to 10.

7.4.6 Prediction of Marks: A Helpful Tool for Subject Choice

The nature of mathematics, where prior knowledge provides the foundation for successive learning, is such that early learning should be of the best standard if learners are to achieve to their highest potential throughout their schooling. The present study shows that it is possible to predict, with a moderate to strong level of precision, the average mark a learner could expect to achieve in subsequent grades (an exception to this is Grade 6 as discussed earlier). These results could be most beneficial when learners have to choose between Mathematics and Mathematical Literacy at the beginning of the FET Phase. Another benefit of knowing what a current mark could translate into in a later grade is that the need for early intervention could be established timeously. The earlier this intervention takes place, the sooner the learner's competencies could be improved and, in so doing, set him on an improved trajectory (Spaull & Kotze, 2015).

It is possible to predict marks in the FET Phase, using Mathematics marks obtained in Grades 8 and 9. Therefore, the guidance and counselling of learners in Grade 9 could be improved if this was used as a tool. Learners who take Mathematical Literacy have the potential of having a higher Admission Point Score than if they took Mathematics due to the considerably higher mark the same learner is likely to attain for Mathematical Literacy. Thus, choosing Mathematics for the FET Phase does not necessarily open doors for a learner. The puropose of selecting Mathematics or Mathematical Literacy must be taken into account.

7.5 LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

7.5.1 Limitations

Several limitations were evident in this case study. A list of these follows:

- A major limitation of this study is that only one school was researched. A further limitation is that it is a single-gender school. Although many of the findings could be applied to other schools, especially Quintile 5 schools, it cannot be assumed that this is necessarily the case. Certain dynamics such as the onset of puberty may affect the findings for girls or learners in co-education schools.
- The school is a high-quintile school. According to Spaull (2013a), there are very few (five out of the 27 they examined) factors affecting learner mathematics performance that low- and high-quintile schools have in common and, therefore, the results and conclusions do not necessarily apply to low-quintile schools. Reddy, Van der Berg et al. (2012) confirm this by stating that the precision of using Grade 8 marks to predict those achieved in Grade 12 is greater for learners in upper-quintile schools than in lower-quintile schools. On the other hand, factors, such as self-efficacy, self-concept and motivation, and the effects of changing schools, puberty and matric examination pressure, apply to all learners, increasing the likelihood that the findings of this study could have applicability beyond the South African Quintile 5 context.
- All data used were retrieved from archives. This means that neither learners nor teachers were interviewed or assessed in person. This made it impossible to assess, for example, which learners had had mathematics intervention or difficulties adjusting socially, or the teaching methods employed in the classroom. Thus, the researcher had to rely on the literature to provide possible explanations for the findings. These

suggested explanations should be investigated empirically before they can be accepted with confidence.

- Promotion marks from the earlier years in the present study were recorded as levels rather than percentages. Thus, midpoints were calculated and used instead. Having the exact percentages would have increased the precision of the data and, therefore, the validity of the correlations and predictions derived from the analysis.
- A variety of assessments, each focusing on different learning areas, were used. It was therefore not possible to determine which topics were more challenging than others. If the specific concepts and procedures tested in the various assessments each year were known, then it would allow for a more comprehensive discussion on what exactly influenced the change in performance over time.
- Not all assessments which contributed to the promotion mark were calibrated to be comparable with one another. Assessments were set and marked by various teachers, implying that the standard was not identical within grades across cohorts as teaching staff changed from time to time. This could have resulted in an examination or test on the same topic which differs in terms of standard from one cohort to another. This limitation is reduced through the application of an extensive moderation policy between teachers at this school.
- Teachers were neither interviewed nor observed with the result that variation in aspects, such as methods of teaching, thoroughness and meeting learners' psychological needs in the classroom could not be determined. Differences in the standard of teaching would have had an impact on the performance of learners beyond the influence of generic longitudinal-related factors such as those discussed, reducing the generalisability of the conclusions beyond this study. This limitation is reduced through the implementation of quality-control policies at the school.

7.5.2 Recommendations for Further Research

The underperformance in mathematics of South African learners necessitates the expansion of research in this area. It became clear during the course of this study that there are several fields related to mathematics performance that require further investigation. The main areas are highlighted here. Firstly, there is a dearth of longitudinal studies of a similar nature in

South Africa. Thus, carrying out similar studies of other (low-quartile or co-education or girls' single-gender) schools could complement this study by shedding light on longitudinal mathematics performance and, consequently, areas to which stakeholders need to pay attention. Secondly, because of the importance of early childhood education and the effect it has on a learner's mathematics trajectory, there would be great benefit in establishing the degree to which early intervention would alter learners' mathematics trajectories. The actual types of interventions required warrants further research.

There is also a need to research specific sub-skills of South African learners from schools of all quintiles. If weaker sub-skills in the various groups can be ascertained, intervention programmes could be provided and/or adjusted to increase effectivity. This could be particularly helpful for Grade 6, where several concepts and procedures are applied simultaneously and for Grades 8 and 9 where concepts learned in primary school are applied in a more complex and abstract manner.

The Senior Phase is definitely a neglected phase that could benefit from future research. An aspect that could be considered for research is determining the most effective ways to meet learners' psychological needs of relatedness, competency and autonomy in the classroom. Another is the role of teachers in assisting learners to make an easier transition from Grade 7 to 8.

7.6 CONCLUDING REMARKS

This research has drawn attention to the value of providing a high-quality education prior to formal schooling. Increasing learner inputs at this stage sets learners on a higher trajectory which potentially continues throughout their schooling. The dividends for strengthening our education system's base will be reaped as learners leave school stronger as a result of the foundation laid 13 or more years earlier.

High school learners need to make informed decisions regarding subject choice. However, for some learners, there is a degree of uncertainty surrounding this process. This uncertainty can be alleviated by providing tools, such as the findings of this research and concrete advice to facilitate the decision-making process.

Not only is there variation across learners' 12 years of formal schooling, but there is also variation within our nation. South Africa is a diverse country with a wide range of educational scenarios. Education research needs to embrace this diversity. It is not a case of one size fits all. Longitudinal studies such as this one, which are tailor-made for the various quintile schools, allow policy-makers to take a step back and examine what is actually happening and the specific needs and challenges in each sector. Only then can all stakeholders truly begin to raise the education bar so that we can compete on the international stage.

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APPENDICES

Appendix A: Summary of format of marks (levels and percentages) available for analysis for Grades 1-12 for the eight cohorts (2009-2016)

Cohort	Grade											
	1	2	3	4	5	6	7	8	9	10	11	12
2009	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	%	%	%	%	%
2010	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	%	%	%	%	%
2011	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	L1-4	L1-7	L1-7	%	%	%
2012	b,a,p,n	b,a,p,n	b,a,p,n	b,a,p,n	L1-4	L1-4	L1-7	L1-7	%	%	%	%
2013	b,a,p,n	b,a,p,n	L1-4	L1-4	L1-4	%	L1-7	%	%	%	%	%
2014	b,a,p,n	L1-4	L1-4	L1-4	%	%	%	%	%	%	%	%
2015	L1-4	L1-4	L1-4	%	%	%	%	%	%	%	%	%
2016	L1-4	L1-4	L1-4	%	%	%	%	%	%	%	%	%

b = 80 – 100%; a = 60 – 79%; p = 40 – 59%; n = 0 – 39%

L1-4: L1 = 0.01 – 34.99%; L2 = 35.00 – 49.99%; L3 = 50.00 – 69.99%; L4 = 70.00 – 100.00%

L1-7: L1 = 0 - 29%; L2 = 30 - 39%; L3 = 40 - 49%; L4 = 50 - 59%; L5 = 60 - 69%; L6 = 70 - 79%; L7 = 80 – 100%

Appendix B: Descriptive statistics for the Mathematics and Mathematical Literacy sets

	Mathematics Set (n=302)						Mathematical Literacy Set (n=160)					
Grade	n	Mean	Standard deviation	Minimum	Median	Maximum	n	Mean	Standard deviation	Minimum	Median	Maximum
1	112	73.3	15.9	19.5	69.5	90.0	42	59.6	22.3	17.5	60.0	90.0
2	115	72.5	14.1	42.5	69.5	90.0	45	58.5	17.2	17.5	60.0	90.0
3	129	70.3	15.4	42.5	69.5	90.0	48	56.1	17.0	17.5	49.5	90.0
4	136	74.9	13.0	42.5	74.0	92.0	49	61.8	13.2	40.0	60.0	90.0
5	147	77.4	12.0	42.5	82.0	93.0	53	63.0	11.5	42.0	61.0	89.0
6	164	73.8	13.5	35.0	76.0	96.0	61	58.2	12.0	36.0	58.0	84.0
7	177	81.2	10.0	48.0	85.0	98.0	73	67.3	10.7	46.0	69.0	90.0
8	266	72.9	13.0	35.5	74.5	98.0	126	50.7	12.7	14.5	50.5	80.0
9	289	68.2	12.1	36.0	69.0	97.0	142	47.1	11.7	27.0	46.5	75.0
10	305	60.8	16.8	18.0	60.0	98.0	94	64.3	12.5	35.0	65.5	90.0
11	307	59.9	16.7	8.0	58.0	98.0	134	69.1	12.11	29.0	70.0	90.0
12	302	64.2	16.1	29.0	62.0	100.0	160	78.8	9.5	45.0	80.0	95.0

Appendix C: Example of statistical analysis results of Mixed Model Repeated Measures for Mathematics set

MMRM Analysis of Mathematics Marks (Grade 1 - Grade 12)
Learners who have Grade 12 Mathematics Mark

The Mixed Procedure

Model Information	
Data Set	WORK.DAT_TRANS
Dependent Variable	Mark
Covariance Structure	Unstructured
Subject Effect	Code
Estimation Method	REML
Residual Variance Method	None
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information		
Class	Levels	Values
Grade	12	Grade_01 Grade_02 Grade_03 Grade_04 Grade_05 Grade_06 Grade_07 Grade_08 Grade_09 Grade_10 Grade_11 Grade_12
Code	302	1 2 6 7 10 12 14 20 22 23 24 25 26 27 28 31 32 34 35 37 42 43 45 47 48 52 54 59 60 63 64 67 71 76 80 82 84 86 90 94 95 100 101 104 105 106 110 111 112 113 115 120 121 122 123 125 126 131 133 134 140 141 144 146 148 149 150 151 153 154 157 167 168 171 172 174 175 178 181 184 185 186 187 188 189 191 201 203 205 206 207 208 209 213 214 215 218 220 221 225 226 227 230 231 233 234 235 236 237 240 241 243 246 247 252 256 260 261 264 267 270 271 272 273 274 277 278 285 286 287 288 290 293 295 297 298 300 301 302 306 309 310 311 317 319 320 322 328 331 332 335 337 343 344 347 349 354 358 359 360 361 363 364 366 367 369 370 372 373 375 377 378 379 380 381 382 384 386 388 389 391 392 393 397 399 400 401 404 405 411 412 414 416 418 420 422 423 426 431 433 435 441 444 445 447 451 452 453 454 455 457 459 460 461 462 465 466 469 470 472 473 479 481 482 483 485 486 487 493 494 495 497 500 501 502 504 505 506 507 515 523 526 530 533 534 535 537 538 543 546 548 552 558 559 560 561 568 572 573 574 576 577 581 582 583 585 586 591 600 605 607 608 609 610 611 613 615 619 621 622 629 631 632 633 635 636 638 639 641 646 647 649 657 658 659 663 666 667 668 678 683 685
Year_Gr_1	8	1998 1999 2000 2001 2002 2003 2004 2005

Dimensions	
Covariance Parameters	78
Columns in X	117
Columns in Z	0
Subjects	302
Max Obs per Subject	12

Number of Observations	
Number of Observations Read	3624
Number of Observations Used	2374
Number of Observations Not Used	1250

Iteration History			
Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	18690.38155522	
1	2	16590.75424451	0.00167923
2	1	16578.17641408	0.00034077
3	1	16575.73089272	0.00003075
4	1	16575.52782473	0.00000036
5	1	16575.52558449	0.00000000

Convergence criteria met.

Estimated R Correlation Matrix for Code 24												
Row	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10	Col11	Col12
1	1.0000	0.7884	0.7234	0.6805	0.6674	0.4495	0.6048	0.4932	0.5640	0.6721	0.7097	0.7030
2	0.7884	1.0000	0.7515	0.7324	0.7083	0.4253	0.5925	0.5298	0.5536	0.5995	0.6211	0.6441
3	0.7234	0.7515	1.0000	0.8352	0.7752	0.3634	0.5087	0.4439	0.5370	0.5718	0.5966	0.5345
4	0.6805	0.7324	0.8352	1.0000	0.8836	0.3828	0.5349	0.5544	0.5126	0.5262	0.5342	0.5486
5	0.6674	0.7083	0.7752	0.8836	1.0000	0.3849	0.5512	0.5762	0.5129	0.5364	0.5524	0.5361
6	0.4495	0.4253	0.3634	0.3828	0.3849	1.0000	0.5312	0.4712	0.4806	0.4869	0.4811	0.4653
7	0.6048	0.5925	0.5087	0.5349	0.5512	0.5312	1.0000	0.6323	0.6009	0.6463	0.6663	0.6134
8	0.4932	0.5298	0.4439	0.5544	0.5762	0.4712	0.6323	1.0000	0.6406	0.6346	0.5400	0.5715
9	0.5640	0.5536	0.5370	0.5126	0.5129	0.4806	0.6009	0.6406	1.0000	0.6774	0.6368	0.6562
10	0.6721	0.5995	0.5718	0.5262	0.5364	0.4869	0.6463	0.6346	0.6774	1.0000	0.7329	0.6518
11	0.7097	0.6211	0.5966	0.5342	0.5524	0.4811	0.6663	0.5400	0.6368	0.7329	1.0000	0.7528
12	0.7030	0.6441	0.5345	0.5486	0.5361	0.4653	0.6134	0.5715	0.6562	0.6518	0.7528	1.0000

Covariance Parameter Estimates		
Cov Parm	Subject	Estimate
UN(1,1)	Code	260.24
UN(2,1)	Code	110.55
UN(2,2)	Code	166.44
UN(3,1)	Code	107.88
UN(3,2)	Code	115.77
UN(3,3)	Code	201.43
UN(4,1)	Code	93.3162
UN(4,2)	Code	93.3155
UN(4,3)	Code	109.43
UN(4,4)	Code	144.88
UN(5,1)	Code	88.4054
UN(5,2)	Code	93.8448
UN(5,3)	Code	101.37

UN(5,4)	Code	91.7687
UN(5,5)	Code	126.69
UN(6,1)	Code	98.4087
UN(6,2)	Code	108.99
UN(6,3)	Code	97.1679
UN(6,4)	Code	97.1787
UN(6,5)	Code	104.58
UN(6,6)	Code	160.76
UN(7,1)	Code	74.5618
UN(7,2)	Code	78.6144
UN(7,3)	Code	80.5789
UN(7,4)	Code	78.4601
UN(7,5)	Code	72.8752
UN(7,6)	Code	94.8206
UN(7,7)	Code	98.6880
UN(8,1)	Code	90.5079
UN(8,2)	Code	97.3943
UN(8,3)	Code	87.3610
UN(8,4)	Code	84.7239
UN(8,5)	Code	94.4141
UN(8,6)	Code	112.31

UN(8,7)	Code	87.1645
UN(8,8)	Code	155.79
UN(9,1)	Code	80.7795
UN(9,2)	Code	89.9918
UN(9,3)	Code	88.5254
UN(9,4)	Code	78.4539
UN(9,5)	Code	79.4475
UN(9,6)	Code	92.7117
UN(9,7)	Code	75.3280
UN(9,8)	Code	115.85
UN(9,9)	Code	138.61
UN(10,1)	Code	89.9370
UN(10,2)	Code	100.70
UN(10,3)	Code	96.6689
UN(10,4)	Code	99.1649
UN(10,5)	Code	98.7449
UN(10,6)	Code	116.07
UN(10,7)	Code	81.4649
UN(10,8)		

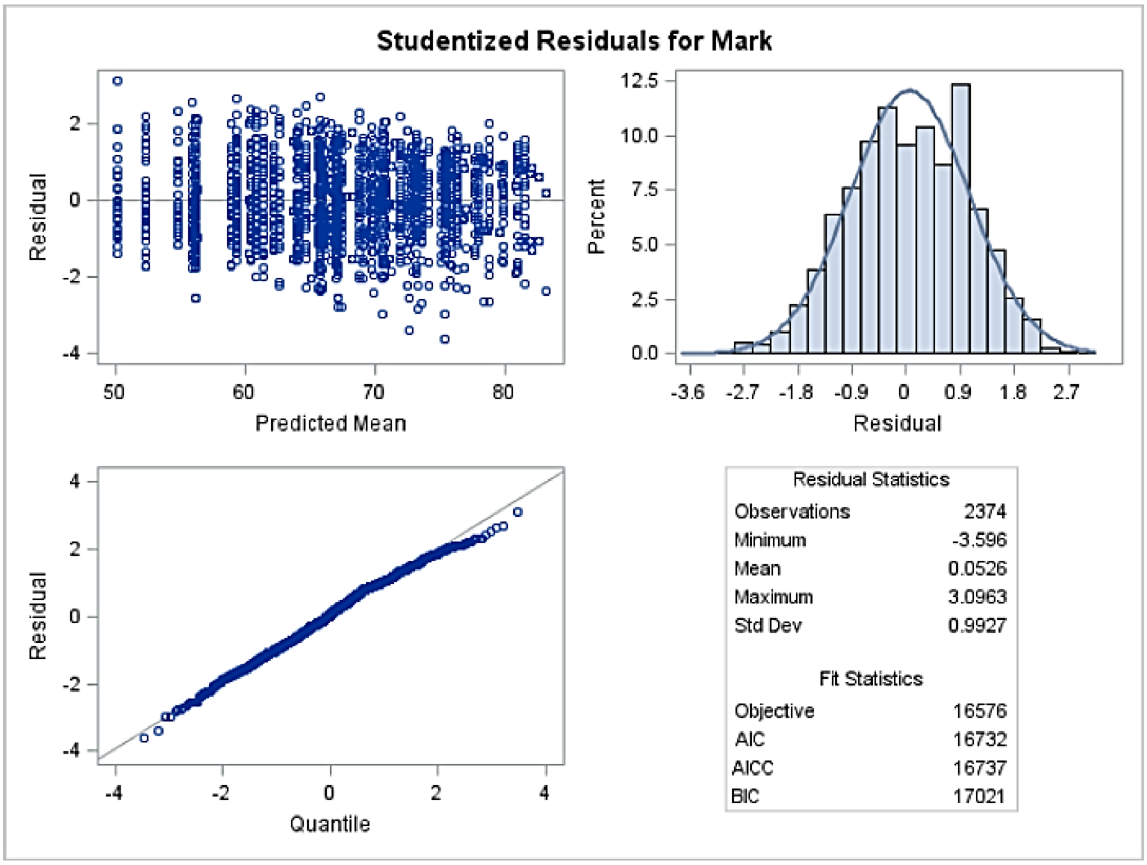
	Code	138.54
UN(10,9)	Code	135.75
UN(10,10)	Code	235.42
UN(11,1)	Code	100.53
UN(11,2)	Code	112.35
UN(11,3)	Code	128.10
UN(11,4)	Code	100.45
UN(11,5)	Code	96.4241
UN(11,6)	Code	110.26
UN(11,7)	Code	88.7240
UN(11,8)	Code	138.28
UN(11,9)	Code	140.38
UN(11,10)	Code	208.63
UN(11,11)	Code	265.06
UN(12,1)	Code	96.6681
UN(12,2)	Code	110.72
UN(12,3)	Code	127.32
UN(12,4)	Code	96.1119
UN(12,5)	Code	94.0029
UN(12,6)	Code	109.06
UN(12,7)	Code	82.9257
UN(12,8)	Code	129.69
UN(12,9)	Code	129.84
UN(12,10)	Code	185.19
UN(12,11)	Code	223.98
UN(12,12)	Code	242.42

Fit Statistics	
-2 Res Log Likelihood	16575.5
AIC (Smaller is Better)	16731.5
AICC (Smaller is Better)	16737.1
BIC (Smaller is Better)	17020.9

Null Model Likelihood Ratio Test		
DF	Chi-Square	Pr > ChiSq
77	2114.86	<.0001

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Year_Gr_1	7	263	1.78	0.0916
Grade	11	177	66.10	<.0001
Grade*Year_Gr_1	77	659	9.44	<.0001

Least Squares Means							
Effect	Grade	Year Gr 1	Estimate	Standard Error	DF	t Value	Pr > |t|
Grade	Grade_01		71.6629	1.4855	117	48.24	<.0001
Grade	Grade_02		71.0884	1.0609	146	67.01	<.0001
Grade	Grade_03		69.3972	1.1277	153	61.54	<.0001
Grade	Grade_04		73.5670	0.9434	158	77.98	<.0001
Grade	Grade_05		76.4375	0.8320	186	91.88	<.0001
Grade	Grade_06		72.6213	0.8863	209	81.93	<.0001
Grade	Grade_07		80.5977	0.6826	214	118.08	<.0001
Grade	Grade_08		72.6166	0.7468	287	97.24	<.0001
Grade	Grade_09		68.4648	0.6922	288	98.91	<.0001
Grade	Grade_10		60.6909	0.8894	293	68.24	<.0001
Grade	Grade_11		60.1108	0.9390	294	64.01	<.0001
Grade	Grade_12		64.1859	0.8980	294	71.47	<.0001
Year_Gr_1		1998	69.1598	1.9025	281	36.35	<.0001
Year_Gr_1		1999	73.7707	1.8913	274	39.00	<.0001
Year_Gr_1		2000	72.8942	1.8499	263	39.40	<.0001
Year_Gr_1		2001	69.1902	1.9279	262	35.89	<.0001
Year_Gr_1		2002	70.0390	1.7737	260	39.49	<.0001
Year_Gr_1		2003	71.5604	1.7380	256	41.17	<.0001
Year_Gr_1		2004	68.1414	1.8863	260	36.12	<.0001
Year_Gr_1		2005	66.2050	1.9076	249	34.71	<.0001



Studentized Residuals for Mark
Residual
Predicted Mean
Percent
Residual
Quantile
Residual Statistics
Observations 2374
Minimum -3.596
Mean 0.0526
Maximum 3.0963
Std Dev 0.9927
Fit Statistics
Objective 16576
AIC 16732
AICC 16737
BIC 17021

Appendix D: Example of results of regression analyses for Mathematical Literacy set

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_1						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	-0.00	-0.00	100	0.03	0.03	100	66.62	66.63	100	2.38	2.33
Grade_11_ML	100	0.06	0.06	100	0.03	0.03	100	65.79	65.92	100	2.03	2.05
Grade_12_ML	100	0.08	0.08	100	0.02	0.02	100	73.78	73.90	100	1.59	1.60
Grade_2	100	0.45	0.44	100	0.05	0.05	100	30.96	31.71	100	3.18	3.13
Grade_3	100	0.17	0.17	100	0.05	0.05	100	47.52	47.11	100	3.69	3.60
Grade_4	100	0.09	0.09	100	0.04	0.04	100	58.74	59.90	100	2.66	2.64
Grade_5	100	0.24	0.24	100	0.03	0.03	100	48.48	48.92	100	2.03	1.99
Grade_6	100	0.17	0.17	100	0.03	0.03	100	48.22	48.28	100	2.05	2.05
Grade_7	100	0.18	0.17	100	0.03	0.03	100	56.92	56.98	100	1.81	1.82
Grade_8	100	0.11	0.12	100	0.03	0.03	100	43.00	42.90	100	2.20	2.18
Grade_9	100	0.07	0.07	100	0.03	0.03	100	42.69	43.18	100	1.94	1.96

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_2						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	0.04	0.05	100	0.05	0.05	100	64.08	63.65	100	2.92	2.93
Grade_11_ML	100	0.20	0.20	100	0.04	0.04	100	58.06	58.07	100	2.34	2.32
Grade_12_ML	100	0.19	0.19	100	0.03	0.03	100	67.40	67.57	100	1.80	1.79
Grade_3	100	0.37	0.37	100	0.07	0.06	100	36.03	35.91	100	4.33	4.14
Grade_4	100	0.20	0.20	100	0.05	0.05	100	52.27	51.67	100	3.16	3.16
Grade_5	100	0.31	0.30	100	0.04	0.04	100	45.03	45.09	100	2.53	2.48
Grade_6	100	0.24	0.24	100	0.04	0.04	100	44.28	44.19	100	2.48	2.49
Grade_7	100	0.22	0.22	100	0.04	0.04	100	54.89	55.18	100	2.27	2.27
Grade_8	100	0.10	0.10	100	0.04	0.04	100	44.25	44.51	100	2.76	2.75
Grade_9	100	0.11	0.11	100	0.04	0.04	100	40.44	40.76	100	2.38	2.35

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_3						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	0.03	0.03	100	0.05	0.05	100	64.91	64.81	100	3.00	2.98
Grade_11_ML	100	0.24	0.25	100	0.04	0.04	100	55.83	55.36	100	2.33	2.34
Grade_12_ML	100	0.20	0.20	100	0.03	0.03	100	67.10	66.90	100	1.84	1.85
Grade_4	100	0.24	0.24	100	0.05	0.05	100	50.40	49.97	100	3.21	3.15
Grade_5	100	0.30	0.29	100	0.04	0.04	100	45.97	45.66	100	2.67	2.63
Grade_6	100	0.18	0.20	100	0.04	0.04	100	48.00	47.80	100	2.67	2.68
Grade_7	100	0.25	0.25	100	0.04	0.04	100	53.19	52.98	100	2.27	2.26
Grade_8	100	0.14	0.13	100	0.05	0.05	100	42.02	42.51	100	2.80	2.79
Grade_9	100	0.18	0.18	100	0.04	0.04	100	36.25	36.62	100	2.34	2.34

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_4						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	0.27	0.26	100	0.06	0.06	100	48.83	49.10	100	4.28	4.24
Grade_11_ML	100	0.26	0.27	100	0.06	0.05	100	52.96	52.49	100	3.65	3.66
Grade_12_ML	100	0.25	0.26	100	0.04	0.04	100	62.11	61.49	100	2.81	2.82
Grade_5	100	0.43	0.41	100	0.06	0.06	100	35.50	36.83	100	3.97	3.92
Grade_6	100	0.27	0.26	100	0.06	0.06	100	41.40	41.12	100	4.00	3.98
Grade_7	100	0.41	0.41	100	0.05	0.05	100	41.33	41.31	100	3.25	3.21
Grade_8	100	0.28	0.28	100	0.06	0.06	100	32.12	32.58	100	4.06	4.06
Grade_9	100	0.33	0.33	100	0.05	0.05	100	25.72	25.20	100	3.35	3.36

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_5						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	0.25	0.24	100	0.07	0.07	100	50.82	51.27	100	4.82	4.83
Grade_11_ML	100	0.33	0.33	100	0.06	0.06	100	49.08	48.57	100	3.98	3.99
Grade_12_ML	100	0.27	0.28	100	0.05	0.05	100	61.33	60.82	100	3.14	3.17
Grade_6	100	0.27	0.28	100	0.07	0.07	100	41.60	40.93	100	4.47	4.45
Grade_7	100	0.32	0.33	100	0.06	0.06	100	47.62	46.51	100	3.96	3.94
Grade_8	100	0.29	0.29	100	0.07	0.07	100	31.90	32.08	100	4.55	4.54
Grade_9	100	0.18	0.17	100	0.06	0.06	100	35.83	36.44	100	4.05	4.07

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_6						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	0.21	0.21	100	0.08	0.08	100	54.31	54.39	100	4.83	4.82
Grade_11_ML	100	0.33	0.31	100	0.07	0.07	100	50.52	51.05	100	3.97	3.95
Grade_12_ML	100	0.35	0.36	100	0.05	0.05	100	57.78	57.42	100	2.97	2.94
Grade_7	100	0.48	0.49	100	0.06	0.06	100	39.65	39.27	100	3.60	3.54
Grade_8	100	0.23	0.23	100	0.08	0.08	100	36.42	36.72	100	4.59	4.56
Grade_9	100	0.22	0.23	100	0.07	0.07	100	34.08	33.35	100	3.97	3.98

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_7						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	0.28	0.29	100	0.09	0.09	100	47.88	47.10	100	6.01	6.09
Grade_11_ML	100	0.42	0.42	100	0.07	0.07	100	41.28	41.38	100	4.85	4.88
Grade_12_ML	100	0.40	0.40	100	0.05	0.05	100	51.23	51.67	100	3.68	3.74
Grade_8	100	0.43	0.42	100	0.08	0.08	100	21.10	21.03	100	5.46	5.45
Grade_9	100	0.48	0.48	100	0.07	0.07	100	14.62	14.66	100	4.50	4.51

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_8						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	0.45	0.45	100	0.07	0.07	100	43.73	43.94	100	3.77	3.77
Grade_11_ML	100	0.36	0.37	100	0.06	0.06	100	51.49	51.35	100	3.31	3.32
Grade_12_ML	100	0.36	0.36	100	0.05	0.05	100	60.47	60.38	100	2.50	2.51
Grade_9	100	0.41	0.41	100	0.06	0.06	100	26.36	26.38	100	3.08	3.09

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_9						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_10_ML	100	0.31	0.31	100	0.09	0.09	100	51.99	52.01	100	4.32	4.31
Grade_11_ML	100	0.32	0.31	100	0.08	0.08	100	54.83	54.95	100	3.67	3.68
Grade_12_ML	100	0.43	0.44	100	0.05	0.05	100	58.23	58.09	100	2.62	2.63

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_10_ML						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_11_ML	100	0.44	0.44	100	0.06	0.06	100	40.68	40.60	100	3.90	3.91
Grade_12_ML	100	0.35	0.34	100	0.05	0.05	100	55.52	55.60	100	3.12	3.11

Learners with at least one ML mark in Grade 10-12

	Parameter											
	Grade_11_ML						Intercept					
	Estimate			SE			Estimate			SE		
	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Dependent												
Grade_12_ML	100	0.62	0.62	100	0.04	0.04	100	35.58	35.50	100	2.77	2.78

Appendix E: Ethical clearance – University of the Free State

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS·UV
EDUCATION
OPVOEDKUNDE

Faculty of Education

13-Oct-2017

Dear Mrs **Deborah Fair**

Ethics Clearance: **"School mathematics performance: A longitudinal case study"**

Principal Investigator: **Mrs Deborah Fair**

Department: **School of Education Studies (Bloemfontein Campus)**

APPLICATION APPROVED

With reference to you application for ethical clearance with the Faculty of Education, I am pleased to inform you on behalf of the Ethics Board of the faculty that you have been granted ethical clearance for your research.

Your ethical clearance number, to be used in all correspondence is: **UFS-HSD2017/0727**

This ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the ethics office to ensure we are kept up to date with your progress and any ethical implications that may arise.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours faithfully

Prof. MM Mokhele
Chairperson: Ethics Committee

Education Ethics Committee
Office of the Dean: Education
T: +27 (0)51 401 9683| F: +27 (0)86 546 1113 | E: NkoaneMM@ufs.ac.za
Winkie Direko Building | P.O. Box/Posbus 339 | Bloemfontein 9300 | South Africa
www.ufs.ac.za

Appendix F: Ethical clearance – Department of Education

Enquiries: KK Motshumi
Ref: Research Permission: DL Fair
Tel. 051 404 9283 / 9221 / 079 503 4943
Email: K.Motshumi@fseducation.gov.za

education
Department of Education
FREE STATE PROVINCE

DL Fair
10 Nettleton Street
Brandwag
BLOEMFONTEIN, 9301

Dear Mrs Fair

APPROVAL FOR AN EXTENSION TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION

1. This letter serves as an acknowledgement of receipt of your request to extent your period to conduct research in the Free State Department of Education.

   Topic: "School Mathematics performance: A longitudinal case study"

   List of schools involved: Saint Andrews School

   Target Population: Information from SASAMS and Saint Andrews School database on school mathematics performance across 19 years.

   Period of research: From the date of signature of this letter until September 2018. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year.

2. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension.

3. The approval is subject to the following conditions:

   3.1 The collection of data should not interfere with the normal tuition time or teaching process.

   3.2 A bound copy of the research document or a CD, should be submitted to the Free State Department of Education, Room 319, 3rd Floor, Old CNA Building, Charlotte Maxeke Street, Bloemfontein.

   3.3 You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.

   3.4 The attached ethics documents must be adhered to in the discourse of your study in our department.

   Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours sincerely

DR JEM SEKOLANYANE
CHIEF FINANCIAL OFFICER

DATE: 08/02/2018

RESEARCH APPLICATION DL FAIR PERMISSION EXTENSION EDITED 6 FEB 2018
Strategic Planning, Policy & Research Directorate
Private Bag X20565, Bloemfontein, 9300 - Room 318, Old CNA Building, 3rd Floor, Charlotte Maxeke Street, Bloemfontein
Tel: (051) 404 9283 / 9221 **Fax:** (086) 6678 678

Enquiries: KK Motshumi
Ref: Notification of research: DL Fair
Tel. 051 404 9221 / 079 503 4943
Email: K. Motshumi@fseducation.gov.za

education
Department of Education
FREE STATE PROVINCE

The District Director
Motheo District

Dear Mr Moloi

NOTIFICATION OF AN EXTENSION TO CONDUCT RESEARCH PROJECT IN YOUR DISTRICT BY DL FAIR

1. The above mentioned candidate was granted permission to conduct research in your district on the 31 July 2017. Approval is further granted for the researcher to continue with her research as follows:

   Topic: "School Mathematics performance: A longitudinal case study"

   List of schools involved: Saint Andrews School

2. **Target Population:** Information from SASAMS and Saint Andrews School database on school mathematics performance across 19 years.

3. **Period**: From date of signature to September 2018. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year nor during normal school hours.

   Research benefits: Investigating mathematics performance spanning 19 years could provide insight into the extent to which earlier performance impacts on subsequent achievement. Weak links between grades and phases may be identified, as well as possible highlighting which grades have the most impact on later grades in terms of mathematics.

4. Logistical procedures were met, in particular ethical considerations for conducting research in the Free State Department of Education.

5. The Strategic Planning, Policy and Research Directorate will make the necessary arrangements for the researcher to present the findings and recommendations to the relevant officials in your district.

Yours sincerely

DR JEM SEKOLANYANE
CHIEF FINANCIAL OFFICER

DATE: 08/02/2018

RESEARCH APPLICATION DL FAIR NOTIFICATION EXTENTSION 6 FEB 2018 MOTHEO DISTRICT

Strategic Planning, Research & Policy Directorate

Private Bag X20565, Bloemfontein, 9300 - Old CNA Building, Room 318, 3rd Floor, Charlotte Mexeke Street, Bloemfontein

Tel: (051) 404 9283 / 9221 **Fax:** (086) 6678 678

Appendix G: Letter of permission from school principal

ST ANDREW'S SCHOOL
BLOEMFONTEIN

To Whom It May Concern

Masters: Deborah L. Fair

Permission is hereby granted to Deborah L. Fair (1983272707) to use Mathematics data captured from St. Andrew's learners. The data will be used strictly for research and individuals whose data is used, will remain anonymous.

Yours sincerely

C.R. Thomas
(Principal)

ST ANDREW'S SCHOOL 23 MAR 2017
PO Box 12331 Brandhof 9324 Tel 051 444 2639 Fax 051 447 6951
email admin@sasb.co.za www.sasb.co.za

St Andrew's School Bfn, PO Box 12331, Brandhof, 9324 • Tel: 051 444 2639 Fax: 051 447 6951 • E-mail: admin@sasb.co.za