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Developing a model of school climate unique to secondary schools in South Africa:

A multilevel analysis approach

A thesis submitted in fulfilment of the

requirements for the degree of

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by

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Abstract

The educational landscape in South Africa is unique and has also seen many changes since the dawn of democracy more than 20 years ago. The apartheid education system was marred by severe inequalities between schools and, for this reason, the democratic government post 1994 established a number of policies and interventions in an attempt to improve access, equity and quality between schools. The country has made significant advances in improving access to education. This is reflected in the Millennium Development Goals progress indicators showing that, as of 2013, almost all learners between the ages of 7 and 15 were enrolled in schools. While great strides have also been made with regard to equity, evidence shows that many schools in South Africa are still largely inequitable.

Education quality, however, is an area that is still of grave concern and the matter requires much attention from educational stakeholders. International studies, such as the Trends in International Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS), use learner performance to measure the quality of the system. Such studies consistently report that South Africa is performing poorly and that large inequalities still exist between schools in the country. Improved quality is associated with effective schools and, in South Africa, only 20% of schools have been found to be functional or effective. Much of research focussed on school effectiveness, both nationally and internationally, however has been explained by factors in the school, including the appropriateness of curriculum content, infrastructure, resources in the school and teacher content knowledge. These factors have been found to be strongly correlated with effective schools.

School climate is a process dimension within the basic school effectiveness model and within South Africa, research looking at its association with achievement is limited. A healthy climate contributes towards an effective school with positive relationships between learners, teachers, school management as well as the community. The study will compare two school climate methodologies to find an appropriate model of school climate within the South African context. The study

will include two data sources; the first is the TIMSS which is an international study administered every four years in participating countries. The second is a school climate survey developed by Tschannen-Moran and her colleagues and administered to teachers as part of the TIMSS study.

The study has three broad aims, the first of these being to observe changes in school climate and the association of such changes with academic achievement over time. Considering that schools in South Africa still remain highly unequal, the second aim is to determine the role that school climate could potentially play in explaining the relationship between socio-economic status and academic achievement. Finally, the study aims to assess which of the two frameworks best explains school climate in the South African context.

The results show that the achievement gap between schools in South Africa has reduced over time, which is indicative of a more equitable education system. School climate is an important process dimension within the school effectiveness framework that explains considerable proportions of the variations in achievement between schools. School climate is able to explain the relationship between SES and academic achievement.

Key Words:

healthy school climate, open school climate, school effectiveness, hierarchical linear modelling, educational policy, mathematics achievement, TIMSS, school climate index, multilevel analysis

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Glossary

ANOVA	Analysis Of Variance
MCAR	Missing Completely At Random
CI	Confidence Interval
DBE	Department Of Basic Education
FCS	Fully Conditional Specification
IEA	International Association for the Evaluation of Educational Achievement
IDB	International Database
ICC	Intraclass Correlation Coefficient
IRT	Item Response Theory
MLE	Maximum Likelihood Estimation
MAR	Missing At Random
NSCC	National School Climate Centre
NMAR	Not Missing At Random
OLS	Ordinary Least Squares
OHI	Organizational Health Inventory
OCDQ	Organizational Climate Description Questionnaire
PPS	Probability-Proportional-To-Size
PPCT	Process-Person-Context-Time
PIRLS	Progress In International Reading Literacy Study
SGB	School Governing Bodies
SACMEQ	Southern Africa Consortium For Monitoring Educational Quality
SDG	Sustainable Development Goals
TIMSS	Trends in International Mathematics and Science Study
UNDP	United Nations Development Programme

Declaration

I declare that this thesis, *Developing a model of school climate unique to secondary schools in South Africa: A multilevel analysis approach*, is my own work, is not copied from any other person's work (published or unpublished), and has not previously been submitted for assessment either at the University of the Western Cape or elsewhere. I confirm that I have read and understood the Department and University's regulations on plagiarism.

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Lolita Winnaar, November 2018

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Chapter 1

1. Introduction

Research has shown that the school environment matters and has an effect on how learners develop and acquire knowledge (Schulze & van Heerden, 2015). Being able to measure and model the effectiveness of a school is thus of the utmost importance so that progress in the schooling system can be monitored.

Over the past twenty years, the educational landscape in South Africa has been through many changes in attempts to rectify inequalities that existed under the apartheid regime. Three outcome indicators, access, equity and quality, have been consistently monitored, not just in South Africa but across the world – this with the intention of evaluating the changes occurring in the education system and in order to ensure that the targets set out in the Millennium Development Goals (MDG) are met (United Nations, 2015). In South Africa, efforts have been made firstly, to ensure that all learners have access to compulsory schooling up to the age of 15 and, secondly, to abolish problems concerning equity related to racial segregation. Such efforts have led to learners having access to any school, irrespective of their skin colour.

As a country, however, South Africa has not performed well with regard to the quality indicator which is considered to be one of the most important indicators and measures of how well the education system is performing. While learner performance in standardised tests is used continuously as a proxy for quality, research undertaken for both national and international studies has shown that South Africa's performance in such tests is exceptionally low (Howie, 2000; Reddy, Zuze, Visser, Winnaar, & Juan, 2015; Yu, 2007; Zuze, Reddy, Visser, Winnaar, & Govender, 2017). Results in internationally standardised tests indicate that South African learners are not performing as well as learners from other upper middle income countries (Reddy et al., 2015) and that large inequalities still exist between schools. Concerted efforts need to be made by all education stakeholders to reduce

this inequality gap, but this will only be possible when issues pertaining to effective schooling are adequately dealt with.

1.1 Background

Research in school effectiveness dates back to the 1960s (Coleman et al., 1966), although there are many different measures and concepts of school effectiveness. This section will explain broadly what school effectiveness is and the overarching model generally used to measure it. Since the focus of the thesis is on school climate, this section will situate school climate within the school effectiveness model. Finally, the South African situation will be explained in relation to school climate.

1.2 Characteristics of effective schools

One of the definitions of an effective school is one that is able to provide all learners with a good quality education (Yu, 2007) by ensuring that all its objectives have been met (Allen, 2015). There are many such definitions by various authors and, thus, the concept of school effectiveness has sparked universal deliberations in attempts to better understand what school effectiveness is and how best to measure it (Creemers & Kyriakides, 2010; Kyriakides, Creemers, & Panayiotou, 2018; Rumberger & Palardy, 2004; Scheerens, 2000; Taylor, 2011; Yu, 2007).

Generally, school effectiveness models are regarded as input-output models. Here, "inputs" refers to the resources and infrastructure provided to schools while the results of learner achievement tests (the "outputs") are generally referred to as the outcomes of the schools concerned. The idea is that providing schools with sufficient material support and adequate facilities should lead to an outcome of improved academic achievement – and that such improved academic achievement will serve as a proxy for an effective school (Heneveld & Craig, 1996). The disadvantage of the input-output model is that the effect of the classroom and what occurs within a school are not taken into consideration.

Sammons (2007) refers to these unknown processes as the "black box" effect (Sammons, 2007). As used here, the term "black box" thus refers to the processes that occur within schools and that ensure that schools are effective, one of these

being a productive school climate (Ellett, Logan, Claudet, Loup, Johnson, & Chauvin, 1997; Rapti, 2012; Rumberger & Palardy, 2004; Scheerens, 1990). Three concepts considered when looking at school climate as a process of school effectiveness are that the school should create a shared vision, create an orderly environment, and emphasise positive reinforcement (Teddlie & Reynolds, 2000).

An effective school is one characterised by an open and healthy school climate with positive relationships between learners, teachers and school management, as well as with the community. Research has shown that effective learning and teaching occurs in schools found to have positive school climates. These include schools that are safe, orderly and disciplined, have positive relationships between management and teachers, as well as between teachers and learners, and a disciplinary framework that all members of the school agree to and abide by (Preble, Preble, & Gordon, 2011). Preble et al. (2011) argue that school climate is the heart and soul of an effective school. It is therefore within the realms of an open and healthy climate that learners, teachers and school management are able to make a difference and to effect positive changes within a school.

1.2.1 South African school realities

School violence and bullying have been found to be products of what occurs in schools that do not have a healthy climate. It is therefore important to measure school climate both more holistically and at a higher level, focusing on issues such as school leadership, communication between management and teachers and respect for the opinions of all.

Schools in South Africa have been – and continue to be – plagued by increasing rates of bullying. Studies such as TIMSS present evidence showing an increase in the percentage of learners being bullied on a regular basis, from 16% in 2002 to 25% in 2015 (Zuze et al., 2017). The media have also been rife with articles pertaining to school violence and bullying, both of which have been linked to cases of suicide amongst victims (Independent Online, 2018; Naicker, 2017).

A number of initiatives, dating back to 2000, were introduced by the Department of Education focussed on improving safety in schools. One such was a partnership

with the South African Police Services in April 2011 called the Collaborative Protocol on the Prevention of Crime and Violence in schools (Department of Basic Education, 2011). In addition, projects and initiatives, such as Signposts for Safe Schools, which was implemented in June 2001 (Department of Education, 2001), as well as programme two of the Tirisano initiative that refers to safe and effective schooling, have been implemented with the goal of improved safety in schools (Department of Education, 2001).

A National School Safety Framework has been developed and is intended to serve as a management tool available to all stakeholders responsible for safety in schools (Department of Basic Education, 2015). The aim of this framework is to enable stakeholders to better understand their responsibilities with regard to school safety. In addition, there have also been interventions that focus on the physical environment or infrastructure of schools. However, it would seem that, even with all these initiatives being implemented, many schools in South Africa remain unsafe, have discipline problems and are subject to varying degrees of violence.

1.2.2 The two school climate frameworks considered in the thesis

Historically, school climate has been measured in a number of different ways, with surveys being administered to learners, teachers and school management. This approach of questioning the various groupings within schools is intended to measure a broad spectrum of perceptions of school climate. While, for a number of reasons, different approaches work for different countries, the bottom line for school climate research is that there is no "one-size-fits-all" approach (Goddard, Goddard, & Minjung, 2015).

Researchers have developed a variety of frameworks to explain and measure school climate. Those frameworks that refer to an open and healthy climate seemed to gain the most traction over the years since it was the first quantitative survey based work ever done. Croft and Halpin (1963) developed the Organizational Climate Descriptive Questionnaire (OCDQ) which was based on eight dimensions of school climate (Croft & Halpin, 1963). They assessed school climate on a scale from closed to open, with an open climate being more favourable and being positively associated with learner achievement (Croft & Halpin, 1963).

Organisational health was a concept expressed by Miles in 1965 who defines a healthy climate as one that thrives in its environment and is able to adapt if environmental changes occur (Miles, 1965). Miles developed the Organizational Health Inventory (OHI) which was based on 10 dimensions of school climate.

Tschannen-Moran, Parish & DiPaola, in 2006 found a number of overlaps between the OCDQ and the OHI and, using appropriate statistical analysis, were able to reduce the framework to four broad dimensions (Hoy & Hannum, 1998; Tschannen-Moran, Parish, & DiPaola, 2006). This framework was referred to as the consolidated school climate framework. Together, the four dimensions – referred to as the School Climate Index – explained 71% of variation in learner achievement (Tschannen-Moran et al., 2006). This combined open and healthy framework is one of the two school climate frameworks considered in this thesis.

The second framework considered is that developed as part of a TIMSS study, the main aim of which was to understand how "educational systems throughout the world deliver and promote learning in mathematics and science" (Mullis & Martin, 2013:61). Research has shown that learning is influenced by experiences within the home, school and community and, when these elements support each other, effective climates for learning can be shaped (Adelman & Taylor, 2007; Berg, Melaville, & Blank, 2006; Osher, Dwyer, Jimerson, & Brown, 2012; Visser, Juan, & Feza, 2015; Wood, Bauman, Rudo, & Dimock, 2017). The framework employed by TIMSS to measure school climate is based on extensive international research into empirical studies that explain factors which create a positive school environment (Mullis, Martin, Foy, & Arora, 2012).

1.2.3 Innovative contribution made by the thesis

Considering that collecting survey data is extremely expensive, one of the important innovations of this thesis is the use of an international study to explore policy concerns that are contextually relevant to a national audience.

By modelling both the TIMSS and open and healthy School Climate Index, the study intends to extend the existing knowledge of school climate as it relates to the South African context. The product of the thesis would be a school climate model

that combines aspects of the two frameworks mentioned (TIMSS climate methodology and the open and healthy School Climate Index) and that this will assist not only policy makers, but also other stakeholders, to understand school climate and its impact on the effectiveness of a school.

On an analytical level, multilevel analysis techniques have been applied. This is unique in the sense that one is able to control learner background factors and isolate the effects that social aspects of the school have on academic achievement. Within developing countries – and specifically in the South African context – multilevel analysis techniques which explicitly model school climate have not been applied very often.

With regard to research on school climate, most previous analysis has been performed using qualitative methods. This thesis makes two additional contributions. Firstly, it is based on quantitative methods and uses a sample of schools and learners that are representative of the school population in South Africa. Considering the inequalities that exist in South Africa, the second contribution focuses on the role that school climate can play in explaining the relationship between achievement and socio-economic status (SES).

1.3 Statement of problem

According to the South African Schools Act 84 of 1996 (South Africa, 1996), a learner has the right to an environment that is not harmful to their well-being. It is in such an environment that learning and teaching take place. Many South African schools, however, are plagued by issues of ill-discipline, disorderly conduct of learners and teachers, and varying degrees of violence occurring in schools (Le Roux & Mokhele, 2011; Zulu, Urbani, Van der Merwe, & Van der Walt, 2004). Issues of ill-discipline is reduced in schools with a positive climate this study proposed to investigate school climate factors associated with learning outcomes and changes that have occurred over time. The results are intended to model the school climate factors that best explain academic (specifically mathematics) achievement in the South African context.

1.4 Aims of the study

The three broad aims of the study were stated thus:

Firstly, using the TIMSS school climate methodology, the study will look at school climate as predictor of school outcomes in South African public secondary schools.

Secondly, the study aims to determine the role that school climate plays in explaining the relationship between socio-economic status and academic achievement. Is school climate able to compensate, mediate and/or moderate the relationship between SES and academic achievement?

The third aim is similar to the first, the difference is that the open and healthy School Climate Index (SCI) will be used as opposed to the TIMSS framework,

Fourthly, the study aims to advance the measurement of school climate in the South African context. This will be done combing the TIMSS school climate methodology and the open and healthy School Climate Index developed by Tschannen-Moran, Parish and DiPaola in 2006.

1.5 Conceptual framework

Schools have often been referred to as organisations (Irish National Teachers' Organization, 1996; Ramdass & Lewis, 2012; Van der Westhuizen, Mosoge, Swanepoel, & Coetsee, 2005; Wang & Degol, 2016) because, like all organisations, schools have sets of norms and rules as well as codes of conduct that all members have to abide by. As with any organisation, schools also have a hierarchy of authority with a principal being the leader of the school.

There is, however, no universal definition of school climate and, similarly, no single framework that best measures school climate. For this reason, the purpose of the current thesis was to test the relationship between two measures of school climate and mathematics achievement. The first framework is based on the TIMSS measure of school climate and includes eight dimensions while the second is the School Climate Index which is composed of four dimensions.

The focus of the School Climate index framework is on the quality of relationships within and around a school (Tschannen-Moran et al., 2006) whereas the focus of

the TIMSS framework is on academic achievement with the understanding that a positive attitude toward academic excellence can overcome issues of resource shortages and ill-discipline (Mullis et al., 2012).

The elements included in TIMSS to measure school climate are the *schools' emphasis placed on academic success* (as reported by the principal), *schools' emphasis placed on academic success* (as reported by the mathematics teacher), the *discipline problems* encountered at the school, a *safe and orderly environment*, *learner's perceptions of bullying* that occurs in the schools, *teacher job satisfaction* and the *challenges that teachers are faced with*. The effect of school climate for different countries using the TIMSS measure of school climate varies considerably. Research has found that school climate has been known to have the greatest effect on academic achievement when compared to variables such as school location and resources (Maxwell, Reynolds, Lee, Subasic, & Bromhead, 2017). However, the variance in learner performance explained by school climate differs from country to country. Results of studies by Ghagar and his colleagues found that, in Singapore and Malaysia, school climate accounted for between 3.5% and 5% of the variation in learner achievement respectively (Ghagar, Othman, & Mohammadpour, 2011). Research done using the United States TIMSS 2007 data established that school climate accounted for almost 20% of the variation in learner performance (Stanco, 2012).

The first dimension of the SCI measure is referred to as *collegial leadership* and describes the nature of the relationship between the principal and the teachers. Collegial leadership refers to how supportive and collegial a principal is towards his staff and to how he or she avoids being perceived as overly restrictive. The second is *teacher professionalism*. This dimension examines the level of teacher satisfaction and commitment to their work and to their learners and also looks at how teachers go beyond what is required to ensure that their learners reach their full potential. The third dimension is that of *academic press*, the extent to which the school places a strong focus on academic achievement. Teachers and principals set high academic goals and learners are expected to achieve these, but the principal and the teachers must ensure that the environment is enabling. The last dimension

is *community engagement* and refers to the involvement of the community and parents in ensuring the continued success of the school.

Figure 1.1 provides the conceptual framework of the thesis and is based broadly on the three analytical chapters (Chapters 4, 5, and 6. The thesis focuses on the process and outcome components of the school effectiveness model mentioned earlier, with the circle on the right in Figure 1.1 representing the outcome, which will be Grade 9 mathematics achievement. TIMSS assesses both mathematics and science however since mathematics and science achievement is highly correlated (see Section 3.4.1), meaning that learners who do well in mathematics would generally do well in science as well. For this reason mathematics was chosen as the dependent variable in the current study.

As a first step, the study set out to investigate the relationship between the various school climate dimensions of the TIMSS study and mathematics achievement – Aim #1 in Figure 1.1. Similarly, the relationship between the SCI dimensions and mathematics were tested – Aim #3 in Figure 1.1. In line with the second aim, the relationship between school climate, SES and mathematics achievement will be tested – Aim #2 in Figure 1.1. Finally, the dimensions from both the TIMSS and SCI frameworks were combined into a single model – Aim #4 in Figure 1.1 – and the relationship with achievement was tested.

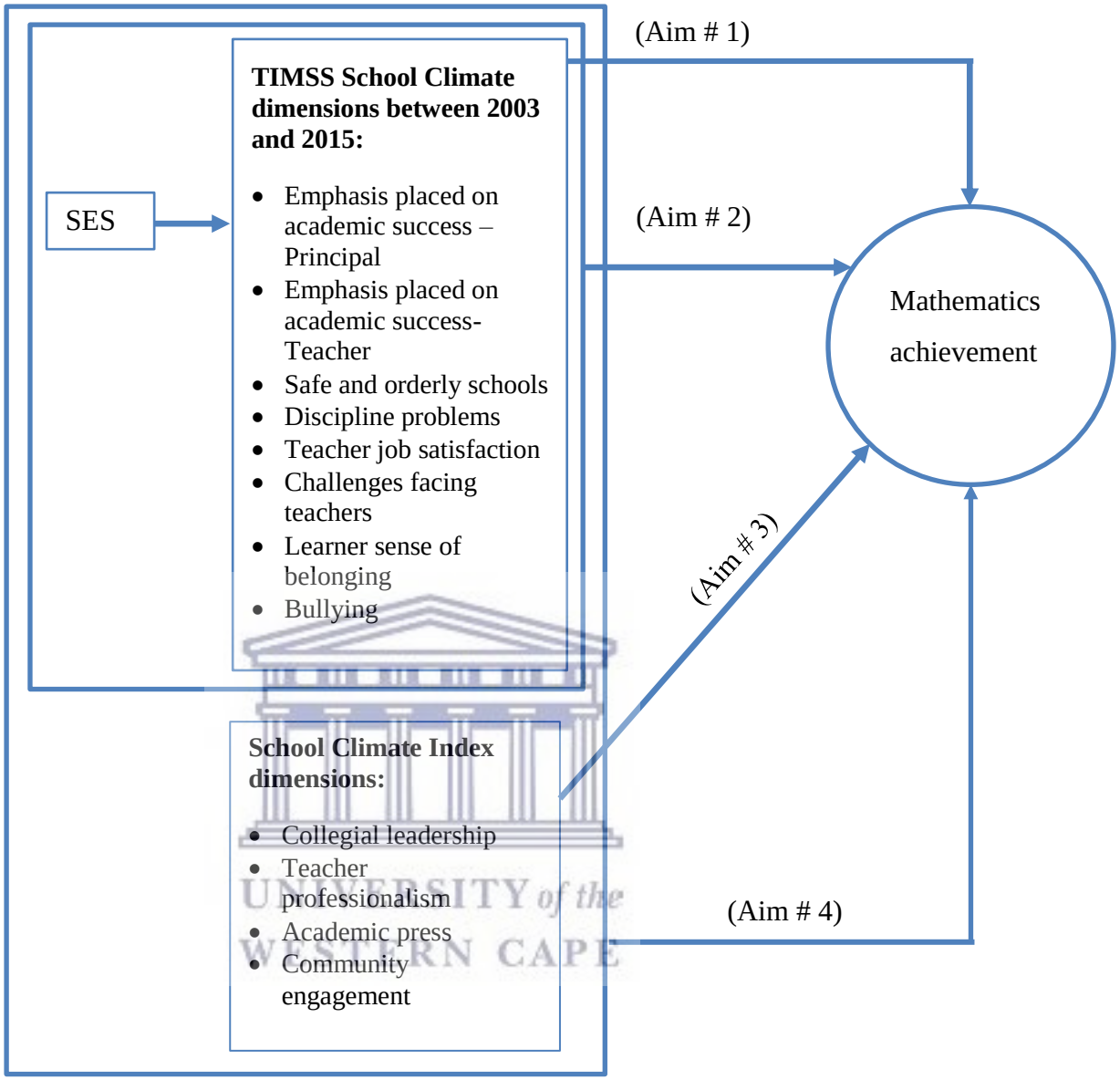

Figure 1.1: Conceptual framework

1.6 Research design and methodology

This study is a secondary analysis using three cycles (2003, 2011 and 2015) of data from TIMSS. In South Africa, TIMSS has been administered by the Human Sciences Research Council (HSRC) since the inception of the study in 1995 when the study was tested at the Grade 8 level for the first time. In 2003, South Africa included Grade 9 in addition to the Grade 8 learners and has since tested at the Grade 9 level only. South Africa added an additional grade to the study; and for the first time in 2015 TIMSS was tested at the Grade 5 level as well. Since one of the main aims of the current thesis was to examine how the relationship between school

climate and mathematics achievement changed over time only the Grade 9 data was analysed.

All the field instruments and consent forms received ethical clearance from the HSRC's Research Ethics Committee (REC 4/16/03/11). Data for the 2003, 2011, and 2015 cycles have been released officially and are accessible from the HSRC Data Curation and Preservation website (http://datacuration.hsrc.ac.za/dataset/load_all_datasets). Data can also be downloaded from the IEA's website however these datasets would exclude all nationalised variables specific to South Africa. In addition, permission to use the data was obtained from the HSRC custodian of the TIMSS data (see letter of permission in Appendix 1.1).

TIMSS is an extremely rich data source and is cross-sectional over time, thus allowing measurements of change over time. In addition, TIMSS collects mathematics and science achievement data which is aligned with the curriculum implemented in a country. As previously stated the basic school effectiveness model has three components; input to schooling, the processes that occur within schools and finally the outputs of schooling. Outputs of schooling encapsulates a number of outcomes to schooling, one of which is academic achievement. The analyses conducted in the thesis will use school climate as a process factor and mathematics achievement as an output factor within the school effectiveness framework.

Research has shown that learning does not take place in confinement but that different dynamics work together to ensure improved teaching and learning (Berg et al., 2006; Leu, Hays, Leczel, & O'Grady, 2005). For this reason, contextual questionnaires were administered to 12000 learners, 300 mathematics teachers and 300 school principals. The Grade 9 TIMSS samples is representative of the secondary schools and learners in the country however due to the nature of the TIMSS design the sample teachers are not representative since an intact Grade 9 class is sampled within a sampled school.

In addition to the collection of data as part of the TIMSS study, permission was granted by the HSRC TIMSS Principal Investigator to administer an addition school climate instrument to all teachers who participated in the TIMSS study. This instrument was based on the school climate framework developed by Tschannen-Moran, Parish and DiPaola in 2006 and referred to as the open and healthy School Climate Index (SCI). Since it was an additional instrument, permission was obtained from the HSRC Ethics Committee to field the instrument (REC 3/16/03/11), see Appendix 1.2.

The data obtained from the TIMSS study in relation to school climate, along with that drawn from the SCI, formed the basis of the current thesis.

1.6.1 Administering the School Climate Index (SCI)

The SCI is a 28-item Likert scale type instrument and covers the broad dimensions of *collegial leadership* (6 items), *teacher professionalism* (8 items), *academic press* (6 items), and *community engagement* (7 items). Appendix 1.3 provides a breakdown of the SCI into its sub-scales (Tschannen-Moran et al., 2006).

Using Cronbach's alpha, Tschannen-Moran et al in 2006 measured the internal consistency of each of the five dimensions (*collegial leadership, teacher professionalism, academic press,* and *community engagement* (Tschannen-Moran et al., 2006) and each displayed strong internal consistency. In addition, they combined the five dimensions to test if a single measure of school climate would also provide a measure that is internally consistent. The conclusion they arrived at was that the individual dimensions, as well as the combined school climate dimension, displayed strong internal consistency.

The SCI instrument, together with the TIMSS teacher questionnaire, was provided to the mathematics and science teachers of each class sampled for the TIMSS study and the teachers were requested to complete these. (Approximately 650 teachers were involved in this exercise). Once the teacher had completed the questionnaires, the fieldworker would collect these, check them for completion and seal them for safety and confidentiality purposes.

1.6.2 Data analysis

The thesis includes three analytical chapters and the analysis methods applied in each are different, but have been based broadly on the following three steps:

1. Descriptive statistics were used to provide information on the distribution, central tendency and dispersion of each of the variables included in the study;
2. Bivariate analysis was used to describe the relationship of each of the school climate variables and the dependent variable, mathematics achievement, using correlations since the dependent and independent variables are continuous; and
3. Multilevel analysis, using Hierarchical Linear Modelling (HLM) software first developed by Raudenbush & Bryk in 2002. The latest version (V7) of the software was used in the thesis and was released in 2013 (Raudenbush, Bryk, & Congdon, 2013), was used to respond to the four aims mentioned earlier. Multilevel analysis, even though appropriate for analysing educational data, is not a commonly used technique in South Africa, hence the section that follows motivates for the use of the software.

1.6.3 Hierarchical Linear Modelling

Due to the nested nature of educational data (for example, learners nested within a class, classes within a school, schools within a district and districts within provinces), this study employed a two-level Hierarchical Linear Model (HLM). The first (lowest) level variables were selected from the learner's contextual questionnaire and served as controls for the learner's home background. Variables at the second level included school climate information and was from the available data on the school and from the teacher's contextual instruments for both the TIMSS and SCI school climate frameworks. By selecting the variables to serve as control at the first level it was then possible to isolate the school climate variables associated with learner performance.

Considering that TIMSS is a cross-sectional study and not a panel study, it would not be possible to have a single model depicting both the trend and the school factors associated with learner performance. A multilevel model was created for each year and since the data included the same variables in each year it was possible to compare the results obtained for each model.

In addition to being able to determine the climate factors associated with learner performance, HLM also allows one to determine if variations in learner achievement scores exist between schools. In South Africa, research shows that large variation exists between schools and this is indicative of inequality between schools (McKeever, 2017; Spaull, 2013; Van der Berg et al., 2011). The aim with HLM is thus to select school climate variables able to explain the variation that exists between schools.

1.7 Outline of the thesis

The thesis consists of seven chapters (see Figure 1.2). Chapter 1 (the current chapter) provides an overview of the thesis as well as a history of school effectiveness and school climate. Chapter 2 situates school climate within the school effectiveness framework and also explains the latter. Details pertaining to the research design and methodology utilised are provided in Chapter 3. The following three chapters (4, 5, and 6) are the three analytical chapters and have been written as articles. The final chapter focuses on the overall conclusions by providing an overview of the results of the three analytical chapters and drawing on the literature review chapter to strengthen the conclusion. In addition, the limitations of the study and recommendations for future research are also provided.

The content of Chapters 4, 5, and 6 is explained briefly as follows:

Article 1: School climate as predictor of school outcomes in South African public schools

Using the three most recent cycles of the South African Trends in International Mathematics and Science Study (TIMSS) data, the study employed multilevel analysis to investigate the relationship between school climate and learner mathematics performance. The aim of this article was to determine if a shift in the type of school climate factors associated with achievement occurred between 2003 and 2015.

Article 2: Understanding school climate and the socio-economic achievement gradient

Strong links have been found between socio-economic status (SES) and learner academic achievement in that learners from homes with a higher SES perform better than learners from homes with a lower SES. By bringing these two core findings together, and by utilising the South African data of the Trends in International Mathematics and Science Study (TIMSS) conducted in 2015, it was possible to realise the main aim of this investigation – that is, to better comprehend the role that school climate plays in understanding the relationship between SES and achievement. Due to the hierarchical nature of educational data, multilevel analysis was employed to respond to the various research questions.

Article 3: Towards a model of an open and healthy school climate in South African secondary schools

The main aim of the study was to determine which framework (or, possibly, which dimensions of the combined frameworks) best explain academic achievement in South African high schools. This was achieved by testing two different frameworks of school climate – the open and healthy School Climate Index and the Trends in International Mathematics and Science Study school climate measure. Since the school and its social context are the focus of the study, a multilevel model (two-levels) was developed, with the variables considered at the first level being used as the control.

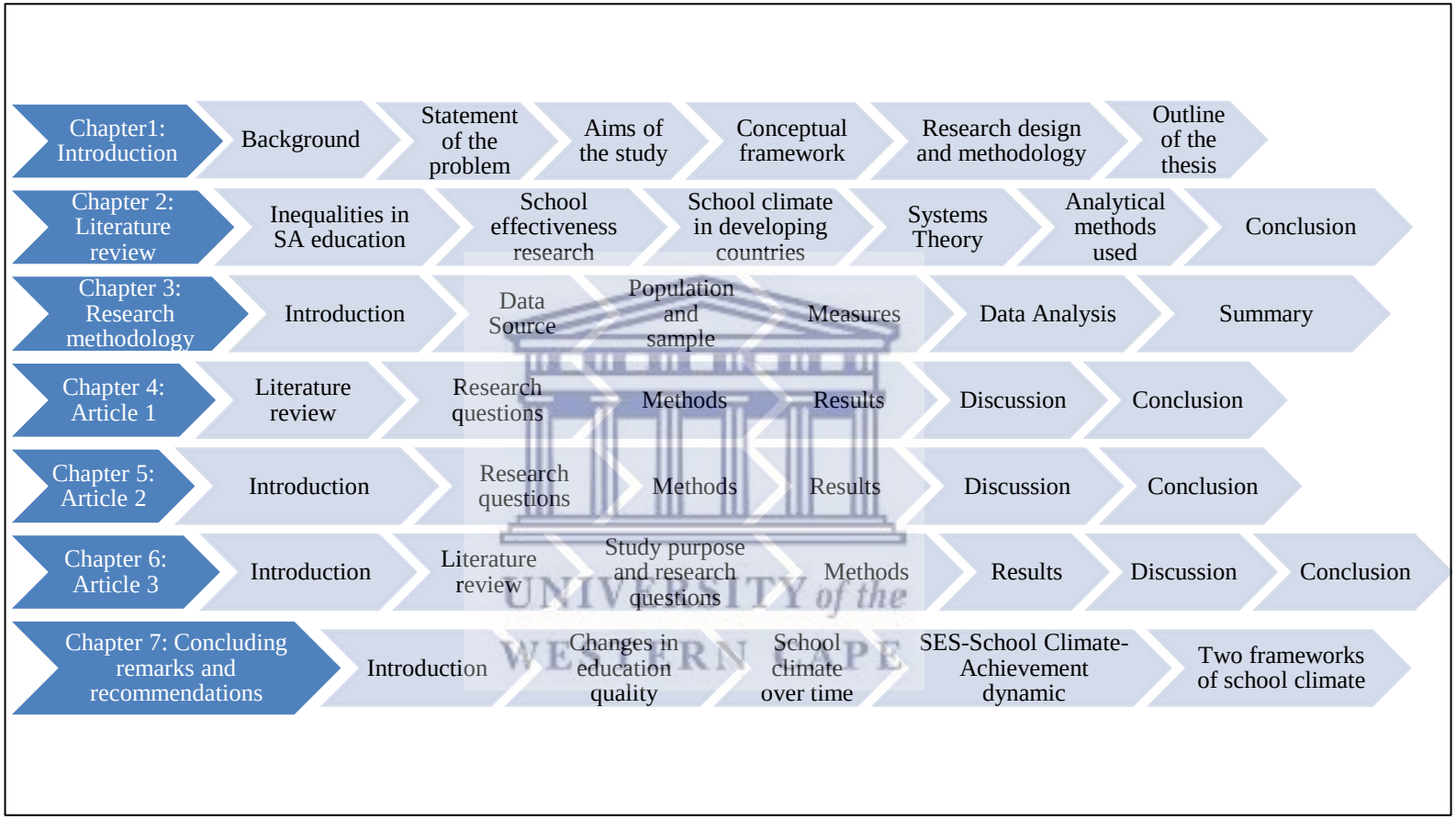

Figure 1.2: Thesis outline

Chapter 2

2 Literature Review

2.1 Introduction

> *"A school is an organization in a changing and complicated social context, bounded with limited resources and involving multiple constituencies such as education authorities, school administrators, teachers, learners, parents, taxpayers, educators, and the public"(Cheng, 1996:3).*

The functioning of a school is multifaceted and consists of five areas: the economic, political, education, cultural and social functions. The economic function is the ability of a school to ensure that learners are equipped with the skills required to cope in a competitive economy. The political function speaks to issues of citizenship and cultivates positive civic attitudes. The education function refers to the curriculum and the implementation thereof while, in terms of the cultural function, schools need to realise that learners come from various religious and cultural beliefs and that they must hence ensure that an awareness of these differences is inculcated. The social function refers to human development and the social relationships that exist between all members of the school (Cheng, 1996).

Schools that are able to fulfil all these functions are referred to as effective schools and are able to provide good quality education and produce well-rounded individuals. In South Africa, there has been a strong focus on the education function and, over time, the curriculum has been changed with improved academic achievement as its eventual outcome. However, with issues such as school-based violence being on the increase, a shift needs to be made towards the social and cultural functions of schooling which speaks directly to Bronfenbrenner's bio-ecological theory and in particular to the micro- and mesosystems. Bronfenbrenner highlights the importance of how the direct and indirect surroundings of an individual, a learner in this case, has an effect on the individual. This is also an area

that has been identified and highlighted in the United States where the Every Student Succeeds Act was passed with a focus on learner and teacher engagement, school readiness and school climate and safety (United States Senate, 2015). The purpose of a school goes beyond academic ability to include social connections, emotional intelligence and positive climates for teaching and learning. School climate has been found to be positively associated with academic achievement and thus related to effective schooling.

The aim of the current literature review is to provide some background to inequalities that still exist within the South African context; what school effectiveness is and differences between the developed and developing world. School climate is then contextualised within the developing world and, finally, some background to the analytical techniques employed is provided.

2.2 Educational inequalities in South Africa

South Africa is rated as one of the most unequal countries in the world in comparison to other upper middle income countries (McKeever, 2017; Van der Berg et al., 2011) with a GINI coefficient, a measure of economic inequality, of approximately 0.61, as determined by the United Nations Development Programme (UNDP). This indicates that, with regard to income, South Africa is very unequal (UNDP Regional Bureau for Africa, 2017). The inequality in South Africa overall is reflected in its education landscape as well.

This inequality is also echoed in the intraclass correlation coefficient (ICC) for education in South Africa. In this context, the ICC indicates the variance in achievement between schools and is thus indicative of the quality of education that learners obtain. The ICC for education in South Africa is extremely high, with research showing this figure as greater than 0.60, depending on the data used to calculate it (Frempong, Reddy, & Kanjee, 2011; Phan, 2008; Van der Berg, 2008; Winnaar, Frempong, & Blignaut, 2015). The closer to 1 the ICC is, the wider the variation in achievement scores – and the more unequal schools are with respect to learner achievement. The aim of any education system is to reduce the variation between schools. The closer that all schools in the country come to homogeneity, the closer they come to offering the same quality of education. To put this into

perspective, a comparison with a few other countries shows ICCs much lower than that of South Africa; for example Finland has an ICC for education of 0.08 (Zuze, Reddy, Visser, Winnaar, & Govender, 2017), which shows that schools in Finland are homogeneous.

In an attempt to reduce educational inequality, the Department of Basic Education (DBE) has assigned all public schools in South Africa a poverty ranking ranging from one to five. Under this ranking, schools in areas of extreme poverty were assigned to quintile one and schools in wealthy areas to quintile five (Department of Education, 2006). The first three poverty rankings are called No-Fee schools (which means that these schools are fully funded by the DBE), whereas the last two poverty rankings are labelled as Fee-Paying schools (Dass & Rinquest, 2017). The idea behind the quintile system was to establish the schools that fall into the first three quintile rankings and to provide them with additional resources both human and physical. Learners who attended these schools were exempt from paying school fees because funding was received from the Department of Education.

At the time of writing, almost twenty five years into the country's democracy, schools are still highly unequal, regardless of the fact that the DBE funds No-Fee schools (Das & Rinquest, 2017) and provides physical and human resources to these schools (Spaull, 2013).

The national government has made significant strides with regard to access to schools for all learners in the compulsory phase of schooling. Racial segregation has been abolished and learners are, in theory, free to attend any school, regardless of their colour. Research, however, shows that despite all the effort made by the DBE; ex-Model C (previously privileged) schools still significantly outperform previously disadvantaged schools (Spaull, 2015; Spaull, 2013). Spaull refers to this inequality as the "dualistic nature" of schooling in South Africa (Spaull, 2013) where only ex-Model C schools remain functional and the vast majority of other schools in South Africa remain dysfunctional.

Policies such as the pro-poor strategy implemented by the national government, as well as the resources provided to No-Fee schools, have not narrowed the inequality gap between the wealthy and poor schools to the extent as expected.

What is required in South Africa is a focus on the process dimension of school effectiveness frameworks.

2.3 School effectiveness research

Effective schools are organised in a way that ensures that learners obtain the best quality education possible. Scholars have been shown to have varied and sometimes interlinking views on what makes an effective school. Research has examined the factors that explain school improvement- and that hence can potentially aid in developing strategies for school effectiveness – a rich source of findings (Great Britain Inspectorate of Schools, 1977; Purkey & Smith, 1983; Reynolds et al., 1994; Tomlinson, 1981; Uline, Miller, & Tschannen-Moran, 1998; Yu, 2007).

In 1977, a study conducted by Great Britain's Inspectorate of Schools found that an effective school is one that is able to actively incorporate its aims with respect to its curriculum, the emphasis placed on academic success, collaboration between teachers, effective leadership, community involvement and a healthy school climate (Great Britain Inspectorate of Schools, 1977).

School effectiveness research has its roots in quantitative sociological studies as well as in economic research. Scheerens & Creemers (1989) specifically focused on the impact that inputs to the system have on outputs which could be academic achievement. Such models are also referred to as education production functions (Hanushek, 1979).

Fullan, while supporting work that focused on the education production function also felt, however, that it was important to look at the throughput aspects of schooling (also referred to as processes) which result in positive outcomes. Fullen supported processes that take place within schools and that mediate the relationship between the inputs to schooling and achievements. However, he found that these processes could not be measured at a single point in time, but that rather that they occurred over time and would yield results gradually (Fullan, 1985).

Scheerens and Creemers felt that the effectiveness models needed more refinement and that the hierarchical nature of schools needed to be taken into account (Scheerens & Creemers, 1989). Models such as these were developed by scholars – Squires (1983), Ellett and Walberg (1979) and Duckworth (1983) among them – who stated that indicators of effectiveness occurred at at least two levels, namely the school and the classroom levels (Duckworth, 1983; Ellett & Walberg, 1979; Squires, 1983). These scholars also state the importance of controlling for the impact of learner background factors when investigating issues of school effectiveness (Scheerens & Creemers, 1989). The conceptual multilevel models developed by Scheerens and Creemers (1989) also identified and highlighted the importance of having a multilevel framework of school effectiveness. The added contribution of these multilevel models was to acknowledge the relationship between the various levels and the fact that these levels are not independent of one another (Scheerens & Creemers, 1989).

These findings were supported by Rumberger and Palardy in 2004, whose work in the area was based on the economic model and was extended to include the classroom, seen as the third level in the multilevel model (Rumberger & Palardy, 2004).

Since the Coleman Report was published by the US government in 1966, extensive progress in the field of school effectiveness research has been made, with some research critiquing what exists and other research extending the body of knowledge. Most of the research, however, has occurred in industrialised countries, with developing countries lagging behind. The sections that will follow will provide some comparison between the developing and industrialised country contexts.

2.3.1 Industrialised countries

In industrialised countries, research in school effectiveness dates back to the Coleman Report which highlighted the importance of the home, specifically SES, in explaining academic achievement noting that the effects of the home environment were much stronger than the effects of the school (Coleman et al., 1966). This finding spurred a plethora of research into the area of school effectiveness in an attempt to prove Coleman wrong. Within the industrialised

world, research into school effectiveness followed three general phases: the education production function; the incorporation of process/throughput factors within schools; and, lastly, attempts to understand the hierarchical nature of education data and to use appropriate analytical tools to explain school effectiveness. Extensive research in these three phases has been done since the findings of the Coleman Report were released.

Tomlinson (1981) states that having clear goals, instructional leadership, a safe and orderly school environment, time on task and continuous assessment of learner progress is vital in ensuring an effective school (Tomlinson, 1981). Similarly, Purkey and Smith supported these findings and extended them to include collegial relationship, administrative leadership, curriculum development and implementation, sense of community, and collaboration (Purkey & Smith, 1983).

Scheerens, in 1990, developed an integrated school effectiveness model which was multilevel in nature and which recognised the importance of the context of schooling. This model thus included the "context-input-process-output" highlight linkages between the variables included within each section of the model (Scheerens, 1990).

Schools that have high expectations for academic success are more likely to do well and, as a consequence of this, would be more likely to be regarded as being effective (Brookover et al., 1978; Dean, 2012; Ekeh, 2014; Hoy, Tarter, & Hoy, 2006; McGuigan & Hoy, 2006). These authors conclude that the importance of the emphasis placed on academic success is understood by all school staff and that they strive to ensure such success through continuous monitoring of learner performance.

The second element in the framework looks at teacher attitudes and their association with learner outcomes. Research into teacher attitudes and their association with achievement found learner performance to be higher where learners have been taught by teachers who have a positive attitude (Caprara, Barbaranelli, Steca, & Malone, 2006; Cohen, McCabe, Michelli, & Pickeral, 2009; Goddard, Hoy, & Hoy, 2000; Mitchell, Bradshaw, & Leaf, 2010). Teacher attitudes encompass confidence

in their own ability to teach, their passion for the teaching profession, their relationships with learners, and collegial relationships with colleagues (Goddard et al., 2000; Goddard & Tschannen-Moran, 2001; Konishi, Hymel, Zumbo, & Zhen Li, 2010; Shah, 2012).

Issues related to orderly conduct and discipline within schools fall within the school effectiveness framework with research suggesting that effective schools ensure that the environments that learners interact with are safe and that learners are disciplined (Cheema & Kitsantas, 2014; Chiu & Chow, 2011; Koth, Bradshaw, & Leaf, 2008; Melhuish et al., 2006; Mitchell et al., 2010; Robinson, Lloyd, & Rowe, 2008). It is in environments such as these that quality teaching and learning take place, which results in higher learner performance.

Having an organised curriculum refers to the school's ability to understand and implement the curriculum effectively. It also speaks to the school's ability to ensure that the foundational concepts in the curriculum are understood by all learners in the school (Cohen, McCabe, Michelli, & Pickeral, 2009; Greenway, 2017; Spicer, 2016).

2.3.2 Developing countries

Unlike in the industrialised world, school effectiveness research in the developing world has lagged considerably. In this section, work in this area and within the developing world context will be highlighted.

Scheerens, in 1999, carried out a review of studies conducted between 1988 and 1992 in the field of school effectiveness research within developing countries. The review found that the emphasis in these studies was placed mostly on the input to schooling and not on the processes that occur within schools (Scheerens, 1999).

Studies during this period concentrated mostly on access to resources, teacher content knowledge and time-on-task and thus a conclusion reached by Scheerens was that research in school effectiveness within developing countries was based predominantly on the education production function. The use of this methodology continued into the late 1990's, with findings also revolving around the inputs to schooling. A few studies included the process factors and used multilevel modelling

as an analytical tool. These included research done by Glewwe, Nyagura, Fuller and Van der Werf and their colleagues and focused on issues of school management and culture (Fuller, Hua, & Snyder, 1994; Glewwe, Grosh, Jacoby, & Lockheed, 1995; Nyagura & Riddell, 1993; Van der Werf, Creemers, De Jong, & Klaver, 1999).

Looking at South Africa and the massive educational inequalities that existed in the 1990's with the transition from the apartheid era to a more democratic society, focusing analytically on the production function made sense. The National Department of Education, at the time, had a tremendous task in trying to reduce the inequality gap between schools by providing previously disadvantaged schools with access to quality physical and human resources (Chisholm, 2004), amongst other things. It would thus make sense that a surge would take place in the research pertaining to school effectiveness, looking at these factors in relation to achievement and noting whether achievement gaps between schools in South Africa were reducing.

A shift in school effectiveness research has occurred in the 2000s, both conceptually and methodologically, with researchers seeing the value in incorporating the throughput or process factors as well as taking the hierarchical nature of education data into account when analytical techniques are chosen.

A study conducted by Lee, Zuze and Ross (Lee, Zuze, & Ross, 2005) analysing data from 14 sub-Saharan countries using multilevel modelling with a focus on school resources, composition and context (input factors) found that inequalities between schools varied considerably from one country to the next, with South Africa showing the highest level of inequality between schools. The findings highlight the importance of the input factors and their association with academic achievement. These authors were able to extend the analytical knowledge; however, the emphasis was placed on the inputs to schooling with no consideration being given to the processes that occur within schools.

A study that focused strongly on the process factors of school effectiveness was conducted in a province (Free State) within South Africa and set out to develop

dimensions of school effectiveness, with the ultimate aim of creating a school effectiveness index that could be monitored over a period of time (Kgaile & Morrison, 2006). The researchers developed three dimensions to explain school effectiveness: teaching and learning; staff participation and collegiality; and leadership and management. The leadership dimension was quite broad and included school climate, professional development and parental consultation.

A study conducted by Carnoy, Chisholm and Chilisa in 2004 compared South Africa to Botswana and focused on the factors that explained why Botswana performed better than South Africa in international assessments (Carnoy, Chisholm, & Chilisa, 2012). Economically, the two countries are similar and spending on education per learner is similar. Botswana, however, is better able to narrow the achievement gap between schools, making schools in Botswana more homogeneous than schools in South Africa.

Advances in school effectiveness research, both conceptually and methodologically, have been made within developing countries. However, there is a need to extend the body of knowledge to focus on the processes that occur within schools and to highlight the importance of multilevel modelling in order to better understand school effectiveness.

2.4 School climate in South Africa

A school principal in 1908 was one of the first individuals to note the importance of school climate in a book he wrote titled "Management of a city school" (Perry, 1908). Perry said that a school should be more than just a structure that houses learners, but that it should instead be a place that provides a quality learning atmosphere to all learners.

Subsequent to 1908, however, the first empirical research done in the area of school climate was carried out by Croft and Halpin in 1963 and by Miles in 1965. From the work of these scholars, two school climate perspectives were developed, namely the openness of school climate and the health of school climate (Croft & Halpin, 1963; Miles, 1965). Croft and Halpin referred to school climate as being the personality of a school, stating that it was measured from closed to open, with an

open climate being preferred (Croft & Halpin, 1963). The aim of the work done by Croft and Halpin was to develop a quantitative instrument which would be able to recognise vital characteristics of interactions between teachers, as well as between principals and teachers (Croft & Halpin, 1963).

A critique of the work done by Croft, Halpin and Miles was that their conceptualisation of school climate was too one-dimensional and, decades later, research has shown that school climate is indeed multi-dimensional in nature (Brookover et al., 1978; Hoy & Hannum, 1998; Hoy, Tarter, & Kottkamp, 1991; Uline et al., 1998).

By employing second-order factor analysis and combining the frameworks of Croft, Halpin and Miles, Tschannen-Moran and her colleagues (Tschannen-Moran et al., 2006) were able to establish four dimensions of school climate which included; collegial leadership, teacher professionalism, academic press, and community engagement. Together these dimensions were referred to as the School Climate Index (SCI) and will serve as one of the frameworks considered in this thesis.

Contextualising school climate within developing countries, and specifically in South Africa, is vital since it is an area that is often misunderstood (Barnes, Brynard, & de Wet, 2012; Scherman, 2002; Waasdorp, Pas, & O'Brennan, 2011).

South African schools have been plagued by concerns of violence and bullying between various members of individual schools (Adelman & Taylor, 2007; Barnes, 2012; South African Human Rights Commission, 2006; Zuze et al., 2016) and although the data shows that levels have stabilised overtime it is unacceptable that a fifth of learners in South African schools are exposed to violence while at school (Burton, 2005; Burton & Leoschut, 2013).

For a child to feel safe within the environment that he/she is in is a basic human right, and it is the responsibility of the school – while the learner is at school – to ensure his/her safety. This is possible in schools with a positive school climate since such a climate has been linked to risk prevention and positively associated with achievement (Cohen et al., 2009).

In 2012, Barnes administered a school climate questionnaire to learners in the Eastern Cape in South Africa, hoping to determine the effect that school climate has on school-based violence. She found that a relationship between school violence and school climate exists in that the more positive the school climate, the lower the incidence of violence occurring in the school (Barnes et al., 2012).

2.5 Bronfenbrenner's bio-ecological theory

Investigating the relationship between school climate and learner achievement is the main theme of the current thesis and research has also found that school climate is strongly linked to the social aspects of not just schooling, but also of the broader community surrounding the school (Brand, Felner, Shim, Seitsinger, & Dumas, 2003; Ruiz, 2016; Scherman, 2002; Tagiuri, Litwin, George, & Barnes, Louis, 1968). Hence Bronfenbrenner's bio-ecological theory (Bronfenbrenner, 1974, 1976, 1977, 1994) formed the basis of the research in better understanding the relationship between school climate and academic achievement.

Urie Bronfenbrenner, a developmental psychologist, was interested in the impact that social and cultural traditions have on human development (Bronfenbrenner, 1994). He introduced the ecological systems methodology in the latter part of 1970, the first of its kind. This methodology consisted of four nested ecological systems that individuals are said to interact with. The Microsystem is the first layer and refers to the immediate environment that learners find themselves in. The setting of this ecological system is composed of four elements, namely place, which could be their homes, schools or classrooms; time (the length of time spent in a place); activities they participate in; and the role played by learners, parents, teachers and principals (Bronfenbrenner, 1974, 1976, 1977).

The Mesosystem is the second layer and supports the Microsystem. It refers to the interactions between learners and their parents or school, teachers with their principals and parents with school staff and so on. An interaction between two role-players within the microsystem is considered as part of the Mesosystem if the interaction impacts individual development (Madeline, 2017). The Exosystem, the third layer, refers to the social system that the learner does not directly operate in but by which the child is indirectly affected, for example, family social networks or

the context of the community within which the child lives. The fourth is the Macrosystem which refers to the cultural values and norms that children are exposed to and that influence their own belief system.

Reacting to criticism received, and conceding his oversight in not acknowledging that he had not adequately emphasised the role that the individual plays in his or her own development (Hampden-Thompson & Galindo, 2017; Madeline, 2017), Bronfenbrenner developed the bio-ecological model. The model was based on four principles which, together, were termed the Process-Person-Context-Time (PPCT) model. The PPCT model had a particular focus on the interactions between these four principles (Madeline, 2017). He also added a fifth system; the Chronosystem, which focuses on the interaction between individuals as well as the various ecological systems over time (Bronfenbrenner, 1994).

Process refers to the continuous interactions between people; Person refers to the individual together with the personal or genetic characteristics they bring to a social situation; Context refers to the four ecological systems from Bronfenbrenner's earlier work. The fourth principle includes both time and the fifth system and focuses on the interaction between individuals as well as the various ecological systems over time (Bronfenbrenner, 1994).

Bronfenbrenner's theory has been applied in investigating how the various systems within the theory are linked to academic achievement. One such analysis, implemented by Rosenfeld and his colleagues, focused on the relationship between the support a learner receives from his/her parents and teachers (microsystem) and academic achievement (Rosenfeld, Richman, & Bowen, 2000). Findings from this research showed strong significant relationships, with learners performing better when they are supported by members of the mesosystem working together and not independently (Rosenfeld et al., 2000).

Findings from a study looking at school structural effects on academic achievement, also applied Bronfenbrenner's theory and found that, while learner-level variables played a significant role in academic success, certain school-level variables, such

as the sense of school climate and social cohesion felt by all school members, is vital in predicting academic achievement (Stewart, 2007; Stewart, 2003).

A third study, conducted in 2016 by Hampden-Thompson and Galindo and looking at the links between academic achievement, school-family dynamics and parental levels of satisfaction with the school, applied Bronfenbrenners' ecological systems theory to explain the existence of these relationships (Hampden-Thompson & Galindo, 2017). The findings suggest that strong relationships between the school and families will lead to higher parental satisfaction levels which, in turn, will impact positively on academic achievement (Hampden-Thompson & Galindo, 2017).

Research in school climate is rooted in the way a schooling environment is able to shape learner behaviours (Wang, 2009) and this, in turn, affects academic achievement. School climate has also been found to be a multidimensional phenomenon which affects learner development. Taking these school climate characteristics into account, it is clear that the Process-Person-Context-Time (PPCT) model should be considered as a theoretical support of school climate research.

Looking at the systems identified by Bronfenbrenner, the life of a learner occurs at a number of levels. The first of these is the immediate environment and its impact on the learner (microsystem). Further levels are the broader societal factors that influence the learner (macrosystem) as well as the interactions between various role players at various levels (mesosystem). School climate speaks directly to the microsystems – however, looking at the various dimensions of school climate, community engagements, for example, would link to the macrosystems and would focus on the societal and cultural environments that learners live in.

2.6 Analytical advancements

As stated earlier, research has proven that schools make a difference in improving learning outcomes (Bowes et al., 2009; Cemalcilar, 2010; Davis & Warner, 2015; Hallinger & Heck, 1998; Lubienski, Lubienski, & Crane, 2008; Scheerens, 1990; Sweetland & Hoy, 2000; Waasdorp et al., 2011) which contradicts findings from

the Coleman Report published in 1966 (Coleman et al., 1966). Coleman found that schools did not make much of a difference and that home SES mattered more. A major criticism of the Coleman report was that an inappropriate regression technique was used (Rumberger & Palardy, 2004).

The nature and structure of educational data is a vital component to consider when investigating appropriate analytical techniques, with findings showing multilevel modelling to be more appropriate (Mitchell et al., 2010; Mohammadpour, 2013; Rumberger & Palardy, 2004; Stewart, 2003; Waasdorp et al., 2011; Winnaar et al., 2015) since educational data is hierarchically ordered in nature. The education system follows a nested structure with learners nested within classes and classes within schools (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010) and, when this hierarchy is taken into account as part of data collection, then multilevel analysis would be appropriate.

Multilevel modelling is fundamentally a regression that has been extended to include various levels of analyses (Huta, 2014) and, in most cases, has one dependent variable which is quantitative in nature and a number of predictors at each of the levels of the analyses (Garson, 2012).

The ultimate objective of multilevel analysis is to measure the variance explained in the dependent variable which, in educational studies, is more often than not learner achievement at the lowest level of the hierarchy (Steenbergen & Jones, 2002). This variance is the sum of the between and within-school variance (Raudenbush, Bryk, & Congdon, 2013) with large between-school variances indicative of large inequalities between schools within the education system (Frempong et al., 2011; Winnaar et al., 2015). Effective schooling in any country would exist only when schools are homogeneous in a good schooling system would mean that learners could attend any school and expect to receive the same quality of education.

Methodologically, Steenbergen and Jones identified three reasons why using multilevel analysis is ideal. The first of these is that it is possible to combine analyses run at multiple levels into a single model. The second is that cross-level

interactions are possible, meaning that tests of moderation are an option. This allows one to test whether predictors at the lower in the analysis are significantly related to predictors at the higher level. An example of this would be the work done by Berkowitz and her colleagues who found that school climate moderated the relationship between socio-economic status and learner achievement (Berkowitz et al., 2015). Thirdly, the findings obtained from multilevel analysis are often generalisable.

Other than the methodological reasons stated by Steenbergen and Jones, there are also statistical impetuses for the application of multilevel analysis. Ignoring the nested nature of data and applying a single-level analysis where school data is disaggregated to the learners' level will lead to standard errors that are incorrectly estimated (Phan, 2008), thus inflating the Type I error. This means that a false positive is created, stating that a relationship exists when it does not (Garson, 2012; Huta, 2014). Unlike ordinary least squares (OLS) regression, the assumption of independent error terms and equal error variance is not assumed in multilevel modelling since learners nested within groups share similar characteristics due, in part, to sampling methodologies applied and would thus affect the covariance structure of data (Huta, 2014). Osborne states that learners who are in the same classroom and taught by the same teacher share similar experiences which, ultimately, would result in homogeneity (Osborne, 2000). Osbourne performed an analysis of data in which he compared academic achievement as the dependent variable with four independent variables at various levels using OLS (disaggregated and aggregated data) and Hierarchical Linear Modelling (Osborne, 2000). He found that the disaggregated analysis provided the best estimate at the learner level but significantly underestimated effects at higher levels, whereas the aggregated analysis overestimated the slopes at the higher levels.

2.7 Conclusion

The purpose of this chapter was to provide some background into school climate and specifically how it is situated. Even though there is no uniform definition for school climate, this chapter has attempted to define the topic both qualitatively as well as quantitatively. The focus of the thesis is on modelling an open and healthy

school climate – a matter covered by the earlier work done by Croft, Halpin and Miles in the 1960s. With progress made in trying to quantify school climate to make empirical research possible, Hoy and his colleagues were able to combine the two school climate measures created by Croft, Halpin and Miles, thus eradicating overlaps and reducing the number of school climate dimensions considerably.

Three of the chapters in the thesis are presented in article form and all three contain substantive literature reviews pertaining to each of the investigated topics. Thus, more detail will be provided later in the thesis. The next chapter will provide some details of the methodologies employed, with particular reference to the data used as well as the sampling, instruments and analytical procedures utilised.

Chapter 3

3 Research Methodology

3.1 Introduction

This chapter provides detailed information regarding the data used, sample selection, the analytical techniques that were used in developing the various school climate indicators, and the analytical methods broadly used in the thesis. As stated earlier, three of the chapters in the thesis were written as articles and hence the format of this chapter will firstly focus on those sections in the three articles that overlapped. Secondly, details pertaining to specific areas within each of the articles will be discussed.

3.2 Data source

The analysis of the thesis is based on secondary data extracted from the Trends in International Mathematics and Science Study (TIMSS) which has been conducted since 1995 by the International Association for the Evaluation of Educational Achievement (IEA). In South Africa the study has been conducted by the Human Sciences Research Council (HSRC) since the studies inception except for 2007 when South Africa opted out of taking part. The main aims of the study is to monitor the health of the education system for a particular country. This is achieved by measuring improvements in instructional practices and learning, using mathematics and science achievement data as well contextual data collected.

South Africa has taken part in the study in 1995, 1999 at the Grade 8 level, in 2003 at both the Grade 8 and 9 levels and, thereafter, only at the Grade 9 level in 2011 and 2015, and at the Grade 5 level for the first time in 2015. Since measuring change in the perceptions of school climate over time is the focus of the first article (Chapter 4), Grade 9 level data for the three cycles (2003, 2011, and 2015) of TIMSS were included in the study. As part of the TIMSS study, a range of instruments are administered within a school. These include a mathematics and science assessment and learner questionnaire that learners are expected to complete, a teacher questionnaire that is administered to the mathematics and science teacher

of the sampled class and, finally, a school questionnaire that the principal was asked to complete. Permission to administer the instruments was granted by the HSRC Research Ethics Committee (REC 4/16/03/11) and permission to use the data as part of the thesis was granted by the HSRC (Appendix 1.1) which is the custodian of the data.

From the background provided in Chapter 1 as well as in the literature review chapter, it is clear that a uniform measure of school climate has as yet not been established. Permission was granted by the TIMSS Principal Investigator at the HSRC to include an additional school climate instrument (called the School Climate Index) that was administered to the mathematics and science teachers who teach the learners in the sampled class, as part of the TIMSS administration that took place the last two weeks of August and the first week of September 2015 October 2015. The school climate dimensions in this instrument were developed by Tschannen-Moran, Parish and DiPaola in 2006 and can be downloaded from http://mxtsch.people.wm.edu/research_tools.php. The instrument was used as is and no changes were made to it. Details pertaining to the various school climate dimensions are provided in Chapter 6. Ethical approval to administer this additional instrument was awarded by the HSRC Research Ethics Committee (REC 3/16/03/11).

3.3 Population and sample

In South Africa, the National Department of Basic Education's "Master list of schools" served as the sampling frame and included schools eligible to be part of the study. Eligibility was dependent on factors such as the size of a school in terms of the learner population of the grade included in the study, the type of school, the curriculum followed by the school and the geographical location of the school. Schools that were excluded were very small schools, special schools that specifically catered to learners with special needs, schools that followed a curriculum completely different to that set by the Department of Basic Education and schools in remote areas where accessibility was a problem. Of the 10010 schools in South Africa offering Grade 9; 795 small schools (less than 10 learners in the grade) and 176 specials schools were excluded from the sampling frame.

A systematic, two-stage probability-proportional-to-size (PPS) sampling methodology was followed with schools being randomly sampled at the first stage. The variables considered for explicit strata were province, the type of school (public or independent) and the language of learning and teaching (English, Afrikaans or dual medium). The school poverty quintile, which is a DBE-assigned poverty ranking ranging from one to five, was used as an implicit stratum. At the second stage, an intact Grade 9 class was randomly selected to form part of the study.

Details pertaining to the realised sample were included in the three articles as these pertain to the analysis performed in those articles. The sample in 2011 and 2015 consisted of approximately 12 000 learners, 300 principals and approximately 300 mathematics and 300 science teachers. In 2003 the sample included 4261 learners, 216 principals and 199 mathematics and 199 science teachers.

3.4 Measures

In this section, details will be provided pertaining to both the dependent variable and the analytical techniques used to create each of the school climate frameworks considered in the thesis. It should be noted that the TIMSS data can be used to describe relationships between variable however causality cannot be implied.

3.4.1 Dependent variable

An assessment booklet was administered to Grade 9 learners in the sampled schools, with half of the booklet consisting of mathematics items and half of science items. The IEA has a substantial item bank which is divided into trends items, released items and new items. During every TIMSS cycle, a set of items is released into the public domain and is freely accessible. For every item released, a new item is added to the bank. Since the item bank grows from one cycle to the next, it is not possible for a learner to be exposed to all items. The IEA thus uses a matrix-sampling approach to assign blocks of items to a set of 14 assessment booklets. Each of these blocks contains approximately 12 to 18 items and each assessment booklet contains two mathematics and two science blocks. To ensure that it is possible to link the 14 booklets, each item appears in two booklets.

Taking the assessment design into consideration, it is clear that not all learners would have responded to the same set of items and it would thus not possible for a learner to have a total score on the assessment. The IEA uses learner responses to the set of items, as well as background information obtained from the questionnaire data, to impute five estimates for each learner that serve as the score when analysis is conducted. This is done using plausible value methodology within the field of Item Response Theory (IRT). For the purposes of the HLM analysis in each of the chapters, all five plausible values will be used. The software will run each model five times (with each plausible value as the dependent variable) and the output for the average across these five models; which is included in the output, will form the basis for interpretation. These plausible values has a score range of zero to a thousand.

Since mathematics and science are highly correlated, learners who perform well in mathematics will most likely also do well in the science component of the test and vice versa. This was also proven when an analysis provided a significant Pearson correlation of 0.93 between mathematics and science and, in addition, is evident from the graph in Figure 3.1. For this reason, the five plausible values for mathematics will serve as the dependent variable in all the analysis in the thesis.

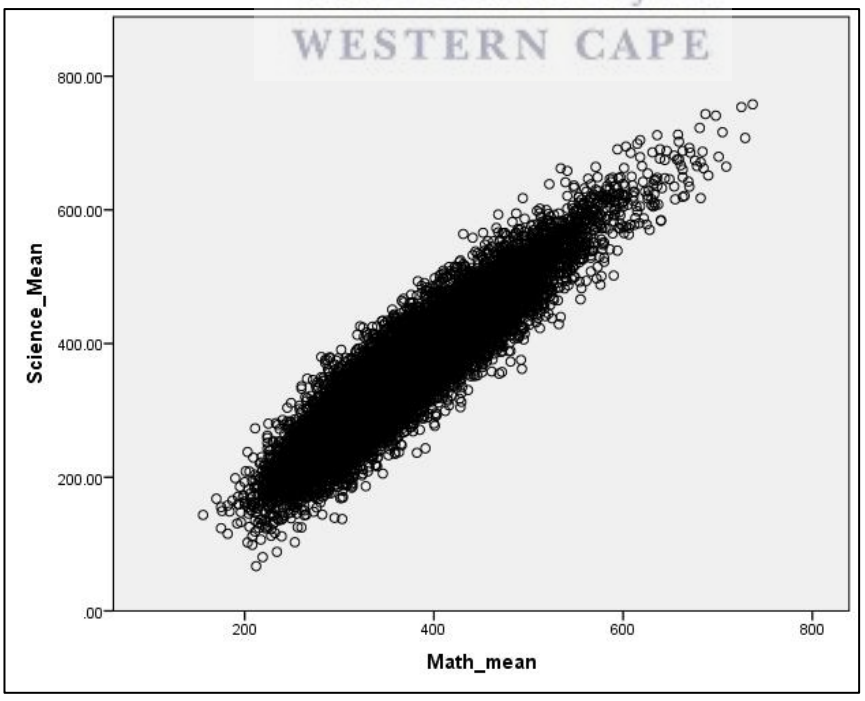

Figure 3.1: Relationship between mathematics and science achievement

3.4.2 TIMSS school climate measures

There are eight TIMSS school climate dimensions in total, however, not all of these are included in the first article that takes account of the 2003, 2011 and 2015 data at the Grade 9 level. Subsequent to 2003, more dimensions were included in the study but, since these did not exist in 2003, they could not be included in the analysis. The methodology used to create all these was the same, but with slight changes to how the final scale for each of the dimensions was created.

In the internationally released data, which can be downloaded from the IEA website, a number of scales were created by the IEA. These included the scales for the various school climate dimensions. A detailed document called "Methods and procedures in TIMSS 2015", created by the IEA, provides details as to how these scales were created. For the purposes of this thesis, all the school climate scales were recreated to ensure consistency across the three TIMSS cycles. The steps provided in the methods and procedures guide was followed when the scales were recalculated.

In the 2015 cycle of TIMSS, additional school climate dimensions were added to the study. These dimensions did not exist in either of the previous cycles and, because the first article (Chapter 4) looks at changes that occurred over time, the school climate measures included in 2003 formed the basis for selecting which dimensions to include in the analysis. For the second and the third articles (Chapters 5 and 6) the full complement of school climate indicators was used since only the 2015 data was take into account in these articles.

IRT was used to create the scales using a partial credit model (Equation 1), since all the items included in each of the scales were Likert-type items (Martin et al., 2015) . Each of the scales measures an underlying construct and the partial credit allows one to determine the probability of a learner selecting a possible option – ranging, for example, from "agree a lot" to "agree a little" – in relation to the construct being measured.

$$P_{x_i}(\theta_n) = \frac{e^{\sum_{j=0}^{x_i}(\theta_n - \delta_i + \tau_{ij})}}{\sum_{h=0}^{m_i} e^{\sum_{j=0}^{x_i}(\theta_n - \delta_i + \tau_{ij})}} \qquad x_i = 0, 1, \ldots\ldots\ldots\ldots, m_i \qquad (1)$$

Where:

$P_{xi}(\theta_n)$ = probability that learner n with location θ on the construct would choose option x on item i out of m_i potential levels within that item;

i = 0,……., m_i possible response levels in item i

j = 0, ……., x_i

h = 0, ……., m_i

m_i = number of response levels;

δ_i = item parameter – provides the location of the item in the construct;

τ_{ij} = response levels of the item.

The scales were developed using a software package called ACER ConQuest version 2.0 which was developed by Wu and her co-authors in 2007 (Wu, Adams, Wilson, & Haldane, 2007).

The IEA calculates weights for the learner, for the mathematics and science teachers and for the principals. Depending on the data used to create each of the school climate scales, the appropriate weight was applied to the data. As an example, the school climate scale that refers to the principal's responses to matters related to the emphasis placed on academic success and thus the school weight was applied.

In addition, for any given scale there needed to have been at least two valid responses per respondent, failing which an estimate was not calculated for that particular respondent. The software created scale scores for each learner using maximum likelihood estimation (MLE) with these scores expressed using the logit metric. Since TIMSS is a trend study, consistency across cycles needs to be ensured and the logit scales that were created were thus transformed using linear transformations. This was done to ensure that scales were comparable across cycles as well as between countries. For each scale, two transformation constants were created (Martin et al., 2015), constant A and constant B. One constant term (constant B) was multiplied by the logit scale score and constant A was then added to the product, thus creating a linear transformation. These IEA-created constants

ensured that the distribution had a mean of 10 (constant A) and a standard deviation of 2 (constant B). Table 3.1 presents the formula used for each of the school climate dimensions.

Table 3.1: Transformation constants and formulae

Dimensions	Data source	Transformation constant (A)	Transformation constant (B)	Formula (A + B * Logit scale score)
Bullying	Learner	7.415134	1.807351	7.415134 + 1.807351 * Logit scale score
Sense of belonging	Learner	7.847376	1.363355	7.847376 + 1.363355 * Logit scale score
Emphasis on academic success	Principal	9.587978	1.101886	9.587978 + 1.101886 * Logit scale score
Safe and orderly	Principal	8.92966	1.031502	8.92966 + 1.031502 * Logit scale score
Discipline	Teacher	8.418512	0.981214	8.418512 + 0.981214 * Logit scale score
Emphasis on academic success	Teacher	9.648219	1.396196	9.648219 + 1.396196 * Logit scale score
Teacher challenges	Teacher	10.279046	2.114581	10.279046 + 2.114581 * Logit scale score
Teacher job satisfaction	Teacher	8.635655	0.874431	8.635655 + 0.874431 * Logit scale score

Source: TIMSS 2003, 2011 and 2015 data (author's calculations)

3.4.3 Open and healthy School Climate Index

The open and healthy School Climate Index (SCI) is composed of four dimensions covering a total of 28 statements that teachers were asked to respond to:

- *CL - Collegial leadership* (composed of 7 items);
- *TP - Teacher professionalism* (composed of 8 items);
- *AP - Academic press* (composed of 6 items); and
- *CE - Community engagement* (composed of 7 items).

The items followed a five-point Likert scale with responses with "Never" coded as 1, "Rarely" coded as 2, "Sometimes" coded as 3, "Often" coded as 4 and "Very often" coded as 5. All negative statements were reverse coded and details pertaining to each of the dimensions are provided in Chapter 6. A list of the statements teachers were asked to respond is provided in Appendix 1.3.

Tschannen-Moran and her colleagues developed three steps to be followed in order to calculate each of the school climate dimensions. In the first step, a mean score per item is calculated. Thereafter, a mean score for each of the sub-scales is calculated and, finally, the score is standardised to a mean of zero and a standard deviation of one for ease of interpretation. Table 3.2 provides the formula developed by the authors to assist in calculating the various school climate dimensions. The scales were created using the methodology designed by Tschannen-Moran, with the only adjustment being standardising to a mean of zero and a standard deviation of one in order to ensure that the results obtained could be compared to the results obtained using the TIMSS methodology.

Table 3.2: Formula to create and standardise the open and healthy SCI

Standard score for collegial leadership (CL) = 1 * (CL – 3.946)/ 0.4127 + 0
Standard score for teacher professionalism (TP) = 1 * (TP – 4.089)/ 0.218 + 0
Standard score for academic press (AP) = 1 * (AP – 3.631)/ 0.276 + 0
Standard score for community engagement (CE) = 1 * (CE – 3.48)/ 0.343 + 0

Source: http://mxtsch.people.wm.edu/ResearchTools/ScoringtheSchoolClimateIndexandOCB.pdf

3.5 Data Analysis

3.5.1 Data weighting

Since the TIMSS study is survey based rather than population based, and also taking the complex sampling methodology into account, it is important that correct weighting procedures are applied. The IEA, as part of the data released to the public, calculates a total weight that is a product of the learner, class and school weights. While this is the weight generally employed when analysing TIMSS data, it is not ideal for use when analysing data using multilevel modelling techniques. For this reason, and for the purposes of the study, a new learner weight was calculated that excluded the school contribution to the total weight. Using the total learner weight as calculated by the IEA, as opposed to the revised learner weight, would mean that the weight of the school would be doubled since the school weight would also be included at the school level of the analysis. The learner weight was calculated as follows:

Learner weight: (WGTFAC2 x WGTADJ2) x (WGTFAC3 xWGTADJ3)

Where:

WGTFAC2 = class weight factor;

WGTADJ2 = class weight adjustment;

WGTFAC3 = learner weight factor;

WGTADJ3 = learner weight adjustment.

3.5.2 Treatment of missing data

How missing data are managed is very important and research has shown that it can bias the results obtained (Van Buuren, 2011; Gibson & Olejnik, 2003). Hence, it is vital that an appropriate analytical technique to handle missing data is selected. Most traditional statistical packages omit missing cases by default when an analysis is performed and this, depending on the amount of missing data, can skew the sample, making it not representative of the population from which it was drawn. This could result in biased estimates and large standard errors.

The way in which missing data is treated is crucial, especially when multilevel modelling is used as an analytical technique. Missing values at the higher level –

for example, the school level – mean that an entire school and its learners would be eliminated from the analysis.

In general, missing data were not a concern in the South African TIMSS study with missingness levels, especially at the school level, being low (Table 5.1 in Section 5.4.2), ranging from zero to seven percent. Since all the variables, selected for inclusion in the current thesis, at the school level were continuous, mean substitution was used to replace the missing data so as not to lose school information which would result in the loss of learner-level data in the HLM analysis.

Table 3.3 provides the level-1 variables included in the study as well as the percentage missing data across the three years. Even though parental education was not included as a level-1 predictor, it is a variable considered when the SES measure was constructed and was also found to have higher percentages of missing data. Details of the variables that constituted the SES measure and how the measure was calculated can be found in Section 3.7.

Table 3.3: Number and percentage of cases missing at the learner level (level-1)

Level-1 Predictor	2003	2011	2015
Parental education	939 (22%)	3999 (33%)	2606 (21%)
Bullying	884 (18%)	741 (6.2%)	314 (2.5%)
Age	119 (2.8%)	106 (0.9%)	102 (0.8%)
Socio-economic Status (SES)	36 (0.8%)	79 (0.7%)	60 (0.5%)
Gender: Boy	6 (0.1%)	3 (0.0%)	

Source: TIMSS data (author's calculations)

Using the SAS software, multiple imputation – a procedure used to create multiple imputed data – was used to address the missing data problem as outlined in Table 3.4. This method only applied to the level-1 or learner level data since mean substitution was used at level-2. These imputed datasets were then included in the HLM analysis. The IEA does not do any imputation but takes into account the different ways in which data may have been missing. The IEA assigns one of four codes for missing information as follows:

- Omitted or invalid: These refer to questions that learners skipped or opted not to respond to as well as responses that were out of range;

- Not administered: These are questions that learners were not able to respond to; for example problems experienced during printing;
- Logically not applicable: If learners responded to questions that were part of a filtered group of questions in the background instruments; and
- Not reached: These codes are assigned when learners have run out of time and were not able complete the test.

The first step in imputing data is to determine the missing mechanism which can either be missing completely at random (MCAR), which means that the missingness does not depend on the observed data, or missing at random (MAR) which occurs when the missingness does not depend on the unobserved data, but on the observed data only. The final mechanism is not missing at random (NMAR) which occurs when missingness depends on the observed as well as the missing data. This was tested using bivariate analysis and the results showed that all the selected predictors were significant at a 95% confidence interval (CI), proving that missing data was MAR.

The second step was to determine the pattern of missingness which could either be monotone or arbitrary and which would determine the multiple imputation method to use. The results showed that the data had an arbitrary missing pattern and, since the variable that needed to be imputed was ordinal, a fully conditional specification (FCS) method was used in the multiple imputation procedure.

Finally, a logistic regression was used to create five imputed datasets which were all used in the HLM analysis.

3.5.3 Descriptive analysis

The descriptive analysis in each of the three articles/chapters was performed on weighted data using output either directly from HLM or using International Database (IDB) Analyzer, an analytical software package created by the IEA specifically to analyse data from large-scale assessments. The descriptive analyses differ slightly depending on the focus of the analytical chapters, but details relevant to a particular chapter are provided within the chapter itself.

3.5.4 Multilevel modelling

Hierarchical Linear Modelling (HLM), a software package created by Raudenbush and his colleagues (Raudenbush et al., 2013), was used to perform the multilevel analysis. One of the benefits of HLM is that it is possible to partition the variance into the within-school and between-school variance. If the between-school variance is greater than 10%, then the use of multilevel modelling is supported. In the case of South Africa, the between-school variance is extremely high, often in excess of 60% as depicted in studies like TIMSS (Zuze et al., 2017). This finding thus supports the use of multilevel modelling for this thesis. This section will provide an outline of the general two-level HLM models while details pertaining to the exact models run for the thesis will be provided in each of the analytical chapters (Chapters 4 to 6).

Another benefit to using HLM is that it facilitates the use of plausible values as well as up to ten imputed datasets in a single run. Five plausible values and five imputed datasets were created when analysing data in the thesis. To ensure that measurement error is reduced, HLM runs a model on each of the imputed datasets and then creates a model for interpretation, which is the average of the five models created.

As with regression analyses, all HLM models have basic assumptions that have to be met before any analysis can be done.

3.5.4.1 HLM assumptions

The assumptions were tested using the 2015 data since this dataset was predominantly used in the thesis.

- **The level-1 residuals (l1resid), the within-school error, are normally distributed with constant variance (homoscedasticity)**. The level-1 residual compares the observed values to the fitted values using a Q-Q plot to test the normality assumption. Figure 3.2 shows that the plot is approximately linear which means that the assumption of normality is met.

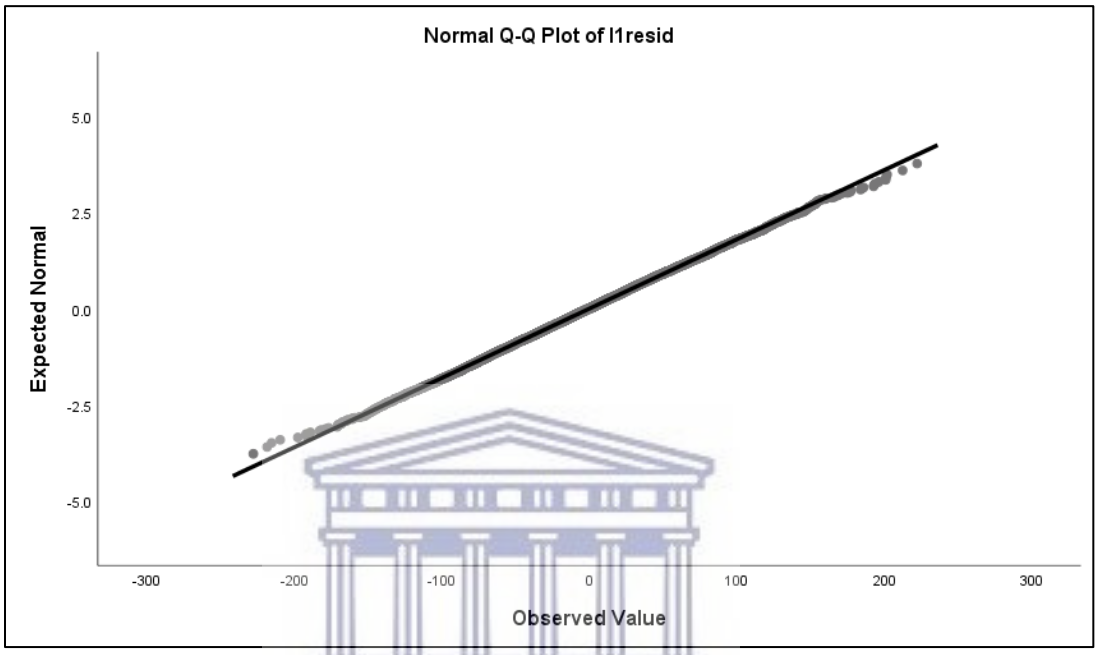

Figure 3.2: Q-Q plot of the level-1 residuals

- **Normality at level-2**.

To test the assumption of normality at level-2, the Empirical Bayes best estimates (ebintrcp) of the level-2 residuals were plotted against one of the continuous level-2 variables (Mean SES) to check if nonlinearity could be detected. Since the scatter plot is not curved (Figure 3.3) this proves that the assumption is met.

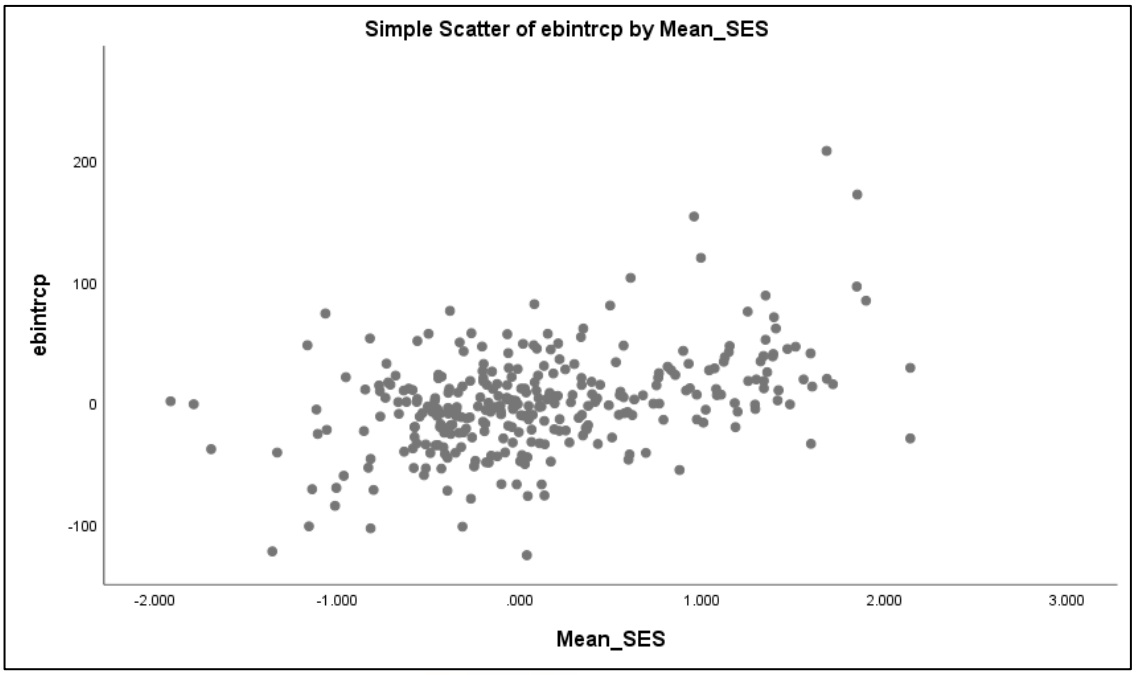

Figure 3.3: Scatter plot of the level-2 residuals

- **Testing homogeneity of level-1 variance**

In this regard, the test for homogeneity was done within HLM and tested whether the variance of mathematics achievement was the same across schools. The null hypothesis of equal variance was rejected (χ^2 (310)= 4320.72, p-value = 0.000) in favour of the alternate hypothesis concluding that the variance in mathematics achievement varied between schools.

3.5.4.2 The basic 2-level HLM model

Formally, there are $i = 1,..... n_j$ level-1 units (e.g. learners) that are nested within each of the $j = 1,... j$ level-2 units (e.g. schools).

Level-1 model:

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{1j} + ... + \beta_{pj} X_{pj} + r_{ij}$$

Where:

β_{pj} *(p=0,1, ... p)* are level-1 coefficients;
X_{pj} is a level-1 predictor *p* for case *i* in level-2 unit *j*
$r_{ij} \sim N(0,\sigma^2)$ normally distributed with mean zero and variance σ^2.

Level-2 model: Each of the β_{pj} coefficients in the level-1 model becomes an outcome variable in the level-2 model:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}Gj + \mu_{0j} \qquad \mu_{0j} \sim N(0, \tau_{00})$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11}Gj + \mu_{1j}$$

Where:

β_{0j} is the intercept for the j^{th} level-2 unit;

β_{1j} is the slope for the j^{th} level-2 unit;

Gj is the value on the level-2 predictor;

γ_{00} is the overall mean intercept adjusted for G;

γ_{01} is the regression coefficient associated with G_j relative to the level-1 intercept;

γ_{10} is the regression coefficient associated with level-1 intercept;

μ_{0j} is the random effects of the j^{th} level-2 unit on the intercept;

μ_{1j} is the random effects of the j^{th} level-2 unit on the slope.

3.5.4.3 Centering variables in HLM

Centering in analysis is the rescaling of variables by subtracting the mean from the variable. In ordinary least square (OLS) regression, rescaling does not have an effect on the significance test. In multilevel analysis, however, the choice of centering is vital as it affects the interpretation of results.

Choice of centering at level-1 in multilevel analysis is extremely important and variables can either remain uncentered, or be group centered or grand centered. Variables that are dichotomised generally remain uncentered and, in the current analysis, this would apply to gender. With grand mean centering, the overall mean is subtracted from the variable. This method of centering is applied to continuous variables. With group mean centering, the variable is subtracted from the group mean which could be the school. This method is used when group differences in the dependent variable are assumed.

In the analysis performed in the thesis, gender was the only dichotomous variable included and was included as uncentered. All remaining variables were grand

centered, except for home SES in Chapter 5 where the variable was group centered since school performance differences were expected and the variable was the focus of the analysis. Details regarding the centering used are provided in the analytical chapters.

3.6 Article 1 (Chapter 4): School climate as predictor of school outcomes in South African public secondary schools

The focus of this article was on changes in the school climate measures over time in relation to academic achievement. In the 2003 and 2011 TIMSS cycles, the school climate measure was composed of five dimensions as opposed to the eight present in the 2015 cycle. To ensure that a trend measure was possible, only the five dimensions common to each study were included in the analysis. In addition, the variables contained in each of the dimensions were compared to ensure that the same measure would be included in each cycle. Reliability analysis was conducted to test whether the variables included in the dimension were suitable.

3.6.1 School emphasis on academic success: Principal report

In the 2011 cycle, an item called '*Teacher job satisfaction'* was omitted from the indicator. However, it was included in the 2003 and 2015 assessments. The reliability was stronger at 0.841 when the variable was included than with it was excluded (0.804). For this reason, it was included in the final scale.

The same was true for the teachers' responses to the set of variables measuring the emphasis placed on academic success.

3.6.2 Safe and orderly school scale (Teachers)

This scale was composed of a few variables that teachers were required to respond to. In the 2011 and 2015 cycle, the scales included five and eight questions respectively. However, in 2003, only three questions were included in the scale. A problem here is that the additional questions from 2011 and 2015 were not asked at all in 2003 meaning that the scale presented in this thesis includes only the three common variables. In the 2011 data, the five scale items provided a reliability of 0.872 and, when run on only three variables, the reliability drops slightly to 0.868. In 2015, the eight scale items included provided a reliability of 0.880 which was

marginally higher than when only the three variables were included, providing a reliability of 0.858.

3.6.3 School discipline and safety scale (School)

This scale consisted of 11 items and asks the extent to which these items are a problem. The responses range from “not a problem at all” to “a serious problem”. The items were reverse coded so that the most positive response is assigned the highest value.

The item content for this scale is the same for all three assessment periods. The reliability of the set of items is 0.914.

3.6.4 Bullying

There were six items included in the bullying scale and these were extracted from the learner questionnaire. The questions asked, and the format in which they were presented, was the same in 2011 and 2015, following a Likert scale-type form. In 2003, however, these questions were posed as a yes/no response type question. For the purposes of this analysis, and to take uniformity into account, the 2011 and 2015 data were recoded to reflect yes/no type responses as in the case of the 2003 data.

Running the reliability analysis with the variables, as it appears in the 2011 questionnaire, provides a reliability of 0.872 while, after the recode, the reliability drops slightly to 0.868 which is quite similar. A further similar result was seen in 2015.

3.7 Article 2 (Chapter 5): Understanding the school climate and the socio-economic-achievement gradient

The main aim of this article was to understand the role that school climate plays in understanding the relationship between SES and academic achievement. Understanding the importance of SES in explaining the achievement gap, and how school climate could aid in reducing that gap, is of importance. In a country commonly plagued by inequality, a decision was made to investigate the measure of SES and to possibly broaden it to go beyond assets in the home which is often used to measure home SES (Taylor & Yu, 2009; Zuze et al., 2016). The IEA does not provide a measure of SES but as previously stated household assets have

commonly been used. For the purposes of both Chapter 5 (Article 2) and Chapter 6 (Article 3) the SES indicator was reconstructed to include not just resources in the home, but also parental education, number of digital devices in the home, number of books in the home and the family structure (Table 3.4). The variables included in the thesis follows those used by the National Centre for Vocational Education Research (Lim & Gemici, 2011)

Table 3.4: Variables considered for inclusion in the SES measure

Variable Name	Variable Label	Variable type	# Categories
NumBooks	Number of books in the home	Ordinal	3
ICT_HME	Number of digital devices in the home	Ordinal	4
ParEduc1	Highest parental education	Ordinal	3
Famstruc	Two-parent household vs other	Binary	2
Q6a	GEN\HOME POSSESS\COMPUTER TABLET OWN	Binary	2
Q6b	GEN\HOME POSSESS\COMPUTER TABLET SHARED	Binary	2
Q6c	GEN\HOME POSSESS\STUDY DESK	Binary	2
Q6d	GEN\HOME POSSESS\OWN ROOM	Binary	2
Q6e	GEN\HOME POSSESS\INTERNET CONNECTION	Binary	2
Q6f	GEN\HOME POSSESS\OWN MOBILE PHONE	Binary	2
Q6g	GEN\HOME POSSESS\GAMING SYSTEM	Binary	2
Q6h	GEN\HOME POSSESS\DICTIONARY	Binary	2
Q6i	GEN\HOME POSSESS\ELECTRICITY	Binary	2
Q6j	GEN\HOME POSSESS\RUNNING TAP WATER	Binary	2
Q6k	GEN\HOME POSSESS\TELEVISION	Binary	2
Q6l	GEN\HOME POSSESS\DVD PLAYER	Binary	2
Q6m	GEN\HOME POSSESS\WATER FLUSHED TOILETS	Binary	2
Q6n	GEN\HOME POSSESS\MOTOR CAR	Binary	2
Q6o	GEN\HOME POSSESS\LANDLINE TELEPHONE	Binary	2
Q6p	GEN\HOME POSSESS\FRIDGE	Binary	2

Source: TIMSS 2015 data (author's calculations)

Since the items making up the list of variables considered for inclusion were either ordinal or binary, the standard factor analysis was not appropriate since its use is dependent on variables being continuous. Use of the Item Response Theory (IRT) procedure in SAS allowed the program to provide information pertaining to the information already provided by each of the variables.

The eigenvalues in Table 3.5 can be used to evaluate the dimension of the latent factors. Since the eigenvalue of the first factor is so much higher than the remaining eigenvalues, it suggests that only one factor for the list of variables is required.

Table 3.5: Eigenvalues of the Polychoric Correlation Matrix

	Eigenvalue	Difference	Proportion	Cumulative
1	6.79118527	4.96282682	0.3396	0.3396
2	1.82835845	0.53422990	0.0914	0.4310
3	1.29412855	0.24029173	0.0647	0.4957
4	1.05383681	0.05572024	0.0527	0.5484
5	0.99811658	0.05064495	0.0499	0.5983
6	0.94747163	0.05406028	0.0474	0.6457
7	0.89341135	0.07214470	0.0447	0.6903
8	0.82126665	0.05886650	0.0411	0.7314
9	0.76240015	0.08744929	0.0381	0.7695
10	0.67495087	0.06664121	0.0337	0.8033
11	0.60830966	0.01583444	0.0304	0.8337
12	0.59247522	0.04187532	0.0296	0.8633
13	0.55059990	0.04641771	0.0275	0.8908
14	0.50418219	0.02330189	0.0252	0.9160
15	0.48088030	0.09095611	0.0240	0.9401
16	0.38992419	0.05305159	0.0195	0.9596
17	0.33687260	0.06756538	0.0168	0.9764
18	0.26930722	0.11905672	0.0135	0.9899
19	0.15025050	0.09817857	0.0075	0.9974
20	0.05207192		0.0026	1.0000

Source: TIMSS data (author's calculations)

For variables with more than two categories, a graded response model was used and, for this reason, these variables have more than one threshold value. For dichotomous variables a two-parameter model was used and only one threshold parameter was calculated. In deciding which of the variables to include, the slope parameter is used because it tells us how well responses to an item discriminate between people based on a threshold value itself based on the standard deviation. Variables where the slope was less than 0.5 were omitted since these did not add much value to the latent trait. From the item parameter estimates (Appendix 3.1), it is clear that number of books in the home, parental education, family structure and a shared ICT device have slopes below 0.5 and they will thus be omitted from the final SES scale.

A decision was made to include the two home resources, "own room" and "study desk" since, when rounded, the slope equals 0.5. Appendix 3.1 provides the item characteristic curves for the final set of variables considered for the SES indicator.

3.8 Article 3 (Chapter 6): Towards a model of an open and healthy school climate in South African secondary schools

The main aims of this article were, firstly, to model the open and healthy SCI developed by Tschannen-Moran and her colleagues and, secondly, to add the TIMSS school climate measures to determine if a joint model could better explain academic achievement in South Africa.

To ensure that the results were comparable between these two frameworks, the data were standardised to a mean of zero and a standard deviation of one.

The SES measure, as discussed in the previous section, was included in the analysis at the first level.

The method according to which each of the SCI dimensions was calculated has also been provided previously.

3.9 Summary

Since three of the chapters in the thesis have been written as articles for submission to various journals – and hence subject to word and page number limitations – this chapter has provided the analytical details that could not be elaborated upon in the articles.

The three chapters that follow will provide a literature review, the analysis plans and the results, as well as a discussion and conclusion responding to the research questions posed in each.

Chapter 4

4 School climate as predictor of school outcomes in South African public secondary schools

4.1 Introduction

The *South African Schools Act 84 of 1996* (Department of Education, 2011) states that a learner has the right to a school environment that is not harmful to their well-being. It is in such environments that productive learning takes place. Such environments, however, do not exist in all South African schools, with many of them being plagued by issues of ill-discipline, disorderly conduct and varying degrees of violence.

School effectiveness research has received a great deal of attention among education policy makers since it is an important indicator of the health of an education system. There are eight broad factors that characterise an effective school; these are school climate, leadership, teacher/learner relations, curriculum instruction, resources and finances, physical environment, evaluation, and parental involvement (Martin, Foy, Mullis, & O'Dwyer, 2011). The focus of this study will be on school climate since effective learning takes place in schools that have a healthy school climate (Dufferin-Peel Catholic District School Board, 2008). In order to eradicate issues of poor safety, ill-discipline and bullying at schools, a preventative rather than a reactive approach to school climate is required.

4.2 Literature review

4.2.1 What is school climate?

There is no universal definition of school climate and research into the area dates back as far as 1962 when the first empirical school climate research was done by Croft and Halpin (Croft & Halpin, 1963) who argued that schools had personalities in the same way that humans do. Howard, Howell, and Brainard (1987) refer to school climate as the atmosphere a school creates for learning where the outcome would be a healthy academic environment (Howard, Howell, & Brainard, 1987).

Defined as the heart and soul of a school, it is open, healthy, warm and safe (Cohen, 2009; Hoy & Hannum, 1998) and incorporates the structural, organisational, social and academic characteristics of a school (Rocco, 2014). It has also been defined as "the set of internal characteristics that distinguish one school from another and influences the behaviour of each school member" (Hoy & Miskel, 2005: 185).

School climate is receiving greater recognition internationally and hence, in December 2015, a new Act referred to as the Every Student Succeeds Act was passed in the United States. This Act shifted the focus to the non-academic dimensions of schooling with the aim of providing a broader measure of learner achievement (United States Senate, 2015). The dimensions identified in the Act are learner engagement, educator engagement, access and completion of advanced coursework, postsecondary readiness, and school climate and safety. Spittler (2017) maintains that school climate should be seen as a comprehensive approach to school improvements consisting of four dimensions namely, safety, teaching and learning, interpersonal relationships, and the institutional environment and which has its foundations in the factors mentioned in the Every Student Succeeds Act.

Koth and her colleagues agree with the notion that school climate is a multidimensional construct and state that it is influenced by the educational and social values (Koth et al., 2008) of all members of a school.

4.2.2 School climate in South Africa over time

Within the South African context, terms synonymous with school climate are school-based violence and bullying in schools. This link, however, is misleading, with these behaviours rather being some of the outcomes experienced by schools with an unhealthy or negative school climate. Research has indicated that school-based violence has been on the rise in South Africa (Ward, Artz, Leoschut, & Burton, 2018), with results from the National School Violence Study conducted in 2012 showing that one in five high school learners reported having experienced violence at school (Burton & Leoschut, 2012). For youth between the ages of 12 and 22, the school has become the most common location of victimisation (Burton, 2005) instead of an environment in which children feel safe. This has undesirable

consequences for their physical and emotional welfare (Leoschut, 2008). Results drawn from the Trends in International Mathematics and Science Study show the issue of bullying is rife, appearing as early as the primary school years with a quarter of Grade 5 learners being bullied on a weekly basis (Reddy, Isdale, Juan, Visser, Winnaar & Arends, 2016). In addition, a substantial number of schools dealing with violence is seen to compete with time spent on teaching (Prinsloo & Neser, 2007).

It is imperative that the focus shifts to dealing with issues of school climate in order to improve the effectiveness of schools. Research has shown that effective learning and teaching occurs mostly in schools that emphasise academic success, are safe, orderly and disciplined, have positive relationships between management and teachers, as well as between teachers and learners, and that have a disciplinary framework to which all members of the school are committed (Preble, Preble, & Gordon, 2011).

For the purposes of this study, an effective school is one characterised by an open and healthy school climate with positive relationships between learners, teachers, school management and parents (Mullis et al., 2012). With school-based violence having reached the magnitude that it has, a more holistic approach is required to ensure safety within schools and the buy-in of all stakeholders is essential.

4.2.3 Interplay between school climate, inequality and learner achievement

South Africa is rated as one of the most unequal countries in the world with regard to income (McKeever, 2017; Taylor, Van der Berg, & Burger, 2012), as measured by the GINI coefficient. Lower values, or values close to 0, are an indication of income equality within a country, while values closer to one refer to high levels of inequality. Statistics released by the United Nations Development Programme (UNDP) show that the GINI coefficient for South Africa is very high, at levels greater than 0.6, when compared to the same coefficient for other upper-middle income countries such as Gabon, with a GINI coefficient between 0.40 and 0.45 and Nigeria where this figure is lower than 0.44 (UNDP Regional Bureau for Africa, 2017). There is a strong correlation between wealth or socio-economic status and education success globally, with learners with wealthier parents

performing better at school (Van der Berg et al., 2011). The occurrence is more prevalent in South Africa when compared to other countries with results showing larger differences in academic achievement dependent on SES groupings (Stephen Taylor & Yu, 2009). Van der Berg (2007), among other scholars, argues that inequality is likely to extend itself from generation to generation with wealthier learners obtaining better quality education, achieving higher post-schooling goals and hence reaping higher rewards within the labour market.

With regard to access to schools, racial segregation that existed during the apartheid regime has been, and continues to be addressed, with schools previously attended by white learners now being more socially mixed and still remaining functional. Many schools previously attended by predominantly black learners even though improvements in functionality has been observed; still remain dysfunctional after more than twenty years (Spaull, 2015). Educational inequalities with regard to socio-economic status or income levels still remain a massive problem, with learners in poverty stricken communities attending highly dysfunctional schools that do not offer quality education.

Research has found a strong correlation between community poverty and school violence (Khoury-Kassabri, Benbenishty, Astor & Zeira, 2004; Stewart, 2003) and, in return, a negative correlation between school violence and learner academic achievement (Ma, Phelps, Lerner & Lerner, 2009; Murtin, Laurent, Barnard, Janse van Rensburg, Reddy, Frempong & Winnaar, 2015; Strøm, Thoresen, Wentzel-Larsen & Dyb, 2013). Astor, Benbenishty and Estrada (2009) postulate that an association exists between poverty and community crime, with higher levels of crime occurring in high poverty communities and, thus, also higher proportions of school violence being expected in these areas.

Numerous authors have showed that a strong association between learner achievement and SES exists, but McEvoy and Welker (2000) argue that the effect of SES is minimised in schools with a positive school climate. What this means is that schools with a healthy climate are more socially equitable with regard to achievement.

Schools with healthy school climates have been known to place high emphasis on academic expectations of learner achievement (Lehr, 2010; Ma & Wilkins, 2002). Some of the outcomes of a healthy school climate are reduced discipline problems (Chiu & Chow, 2011), improved morale among members of the school and enhanced staff performance (Heck, 2000), all of which, in turn, result in improved learner achievement (Goddard et al., 2000).

4.2.4 TIMSS framework of school climate

Research has shown that learning is influenced by experiences within the home, school and community and, when these elements support each other, effective climates for learning can be shaped (Anderson, 1982). Because TIMSS is an international study, the basis of the school climate definition is broad and cuts across contexts. The framework employed by TIMSS to measure school climate is based on extensive research into empirical studies that explain factors which create a positive school environment (Mullis, Martin, Foy & Arora, 2012). The elements included in TIMSS to measure school climate are the schools' emphasis on academic success, a safe and orderly environment, school discipline and safety, and learner's perceptions of bullying that occurs in the schools.

The emphasis that schools place on academic success has been known to show improved academic results, irrespective of the socio-economic status of the school (McGuigan & Hoy, 2006). However, this is possible only when various members of a school also place emphasis on academic success. In TIMSS, emphasis on academic success includes factors such as: teachers' understanding of school curricular goals, teachers' success in implementing the curriculum, teachers' expectations for learner achievement, parental support for achievement and, finally, the learners' desire to do well.

A stable learning environment is possible in schools where learners and teachers feel safe and where there are no problems with discipline, a state of affairs which has been found to be strongly linked with academic success (Mitchell, Bradshaw & Leaf, 2010). Another school climate factor that TIMSS placed emphasis on is issues surrounding bullying in schools. According to the TIMSS framework, bullying

involves “aggression or negative behaviour intended to harm or bother less physically or psychologically powerful persons” (Mullis et al., 2012: 274).

4.3 Research questions

- Has the variance in learner achievement among public schools reduced from 2003 to 2015?
- How are selected learner contextual characteristics associated with learner mathematics achievement?
- After controlling for learner contextual characteristics, what are the school climate components that are associated with learner mathematics achievement in 2003, 2011 and 2015?
- How much of the variance between public schools is explained by the school climate components in 2003, 2011 and 2015?

4.4 Methods

4.4.1 Data

This study is a secondary analysis using three cycles of South African data from the Trends in Mathematics and Science Study (TIMSS), collected in 2003, 2011 and 2015. Data for the 2007 cycle does not form part of the current study because South Africa did not administer the study in that cycle. TIMSS is administered every four years and is cross-sectional over time, thus allowing measurements of change over time. The TIMSS sample is selected using a two-stage stratified sampling methodology with school selection done using a probability proportional-to-size (PPS) sampling method. Schools are selected at the first stage with province, language of learning and teaching (English, Afrikaans, dual medium) and school type (public and independent) serving as the stratification variables. Martin, Mullis, and Hooper (2016) provide details on the methods and procedures used through the lifecycle of the TIMSS project, and one of their chapters focuses on the sampling methodology. In 2003, the TIMSS sample included only public schools. Accordingly, and to ensure comparability across years, only public schools were included in the analysis of subsequent surveys. Table 4.1 presents the sample numbers for the schools, teachers and learners in the realised sample of public schools.

Table 4.1: Realised samples for 2003, 2011 and 2015

Realised Sample	2003	2011	2015
Schools	216	256	254
Teacher Mathematics	199	280	286
Learners	4261	11049	11420

Source: TIMSS data (author's calculations)

Because TIMSS is sample based, the international study centre calculates different weights to enable representative population-based analysis of the data. The learner weight is the most commonly applied weight for single-level analysis. It is the product of the school, class and learner weights. With multilevel analysis, and as an example when looking at two-level analysis, the learner weight at the first level would not be appropriate (Rutkowski, Gonzalez, Joncas, & von Davier, 2010). In the case of the current study, a recalculated learner weight was applied at the first level and the mathematics teacher weight provided by TIMSS was utilised at the second level. The new learner weight was the product of the learner weight and the class weight only. This was done in order to separate the school weight from the total learner weight since analysis at the first level has the learner as the smallest unit of analysis (Rutkowski et al., 2010).

The learners, principals and teachers from public schools who participated in TIMSS in the three years were included in the analysis.

4.4.2 Measures

Data were extracted either directly from the background questionnaires completed by learners, principals and teachers or from scales created according to Item Response Theory (IRT) utilising the ConQuest software package (Adams, Wu & Wilson, 2015). To ensure comparability over the three time points, the variable selection for each of the scales is exactly the same. The following two sub-sections will provide details of the variables selected for the current study.

4.4.3 Outcome variable

An assessment in mathematics and science is done as part of the TIMSS study to measure what Grade 9 learners know in terms of curriculum content. Due to the great number of items that have accumulated in the TIMSS item bank from one cycle to the next, it is not possible for learners to respond to all items. TIMSS thus

uses an item block design where items are distributed into blocks of fourteen items each and spread across 14 test booklets with overlapping blocks in all booklets. For this reason, learner scores obtained on completed items are combined with the background data of similar learners and, using Item Response Theory (IRT) scaling methods, estimated scores for learner outcomes are calculated. Five estimates or plausible values for each learner are drawn to account for errors that may occur during the estimation process (Martin et al., 2015). These plausible values are not intended to be estimates of individual learner scores, but rather imputed scores of learners with similar characteristics. When any analysis is considered, all the imputed scores need to be considered individually because taking the average of these will not yield suitable estimates of individual learner scores (Martin et al., 2015).

For the purposes of this study, the five plausible values for mathematics will serve as the outcome variable and a suitable analysis package will be used (details provided later in the article). Research has found strong correlations between mathematics and science for TIMSS (Kurumeh, Igyu, & Mohammed, 2013; Oyedeji, 2011; Wang, & Ma, 2016). The conclusion would thus be similar and hence, for the current analysis, only mathematics is included.

4.4.4 Learner level

Variables at the learner level were selected from the learner background questionnaire and variables were considered only if they were present in all three years. The learner variables in the model serve as controls only, as the main focus is on the school/teacher-level variables.

Learner age was the first variable selected and was continuous in nature, ranging from 14 to 20. The gender variable was dichotomised, with boys being coded as 1 and girls as 0.

A scale measuring home SES was created and encompassed the physical resources which learners have access to at home. The 2003 home SES scale included 16 items; the 2011 scale included 18 items, and 16 items were included in the 2015 study. The variables were coded as 1 if a household had an item and zero if not. All

the items in each of the years were totalled where a score of 16 (2003), 18 (2011) and 16 (2015) indicated learners having all the items in their homes and zero if a learner having selected "no" in respect of all the items. In order to make comparison across years possible, the three scales were standardised to a mean of zero and a standard deviation of one within years.

The bullying scale contains six statements learners were asked to respond to namely; how often they were made fun of or called names, left out of games or activities by other learners, someone spread lies about them, something was stolen from them, hit or hurt by other learners, and made to do things [they] did not want to do by other learners. The response options in 2003 were "yes" or "no". However, these were converted to Likert scale-type statement in 2011 and 2015 where "at least once a week" was coded as 1, "once or twice a month" coded as 2, "a few times a year" coded as 3 and "never" coded as a 4. To ensure the scale was the same across the three years, the 2011 and 2015 data were recoded to "yes" or "no" as well, with "yes" being coded as 1 and "no" as zero. This meant that that the code 4 was recoded to 0 referring to learners who said they were never bullied and codes 1, 2, and 3 coded to 1 meaning that learners were bullied.

Item Response Theory, as prescribed by TIMSS, was used to create the bullying indicator (refer to Section 3.4.2 for more detail) which was a continuous variable.

4.4.5 School climate measures (School/Teacher Level)

Using the TIMSS framework, five school climate scales were created for each of the three-year cycles included in the study. To ensure that it was possible to adequately measure change over time, the same set of variables for each of the school climate measures was included across years. Where necessary, all variables were recoded so that the most positive responses had the highest values. A reliability analysis was performed for each of the scales to ensure internal consistency and to determine whether a set of items, when grouped, would measure a particular construct reliably. A Cronbach's alpha of between 0.5 and 0.7 is considered as moderate internal consistency, while a value higher than 0.7 would be considered as indicating high internal consistency.

This was followed by creating the scales using the ConQuest IRT package (Adams et al., 2015) and adhering to the strict guidelines provided by the International Association for the Evaluation of Educational Achievement (IEA) (Martin & Foy, 2015).

Emphasis placed on academic success was the first indicator developed. Two such scales were developed, one from the perspective of the principal and the other from the perspective of the teacher. The same set of statements was posed to both the principal and the mathematics teacher. On a scale from 1 (very low) to 4 (very high), they were asked how highly they rated the following within their school:

- Teacher's job satisfaction;
- Understanding of curricular goals;
- Implementation of the curriculum;
- Teacher expectations of learner achievement;
- Parental support of learner achievement; and
- Learners' desire to do well.

The Cronbach's alpha for the set of teacher-level variables was 0.801 and 0.841 for the principals' response to the variables.

Safe and orderly school, with a Cronbach's alpha of 0.868, consisted of three statements asking teachers the extent to which they agree or disagree with safety concerns about their school. The statements concerned whether they felt that the school was in a safe neighbourhood, whether they felt safe at school, and whether the school security policies and practices were sufficient. The original TIMSS scale contained five statements in 2011 and 2015, but because only three were included in 2003 those were the only variables maintained in the current study. The Chronbach's alpha dropped slightly from 0.872 to 0.868.

School discipline and safety consisted of 10 items and asked the principal the extent to which late arrival at school, absenteeism, classroom disturbances, cheating, profanity, vandalism, theft, intimidation or verbal abuse among learners, physical injury, and intimidation or verbal abuse among staff were problems at the school.

The responses range from “not a problem at all” to “a serious problem”. The items were reverse coded so that the most positive response is assigned the highest value.

The item content for this scale was the same in all three assessment periods. The Cronbach’s alpha of the set of items was 0.914.

The learner **Bullying scale**, which was described earlier as part of the learner-level variables, was aggregated to the school/teacher level and included as one of the components of school climate. The Cronbach’s alpha for the set of items included was 0.868.

4.4.6 Data analysis plan

4.4.6.1 **Descriptive analysis**

Correlations were performed to evaluate if there were associations between mathematics achievement and each of the school climate components. The coefficient of determination (R^2) was reported to determine the amount of variation explained by each of the school climate components. The analysis was performed using International Database (IDB) Analyzer; an analysis package designed by the IEA specifically for large-scale assessment projects that take the complex TIMSS sampling methodology into account (International Association for the Evaluation of Educational Achievement, 2017).

4.4.6.2 **HLM**

Because we are using school characteristics to explain differences in learner-level achievement, using simple linear regression would be inappropriate (Lee, 2000). Traditional statistical methods such as analysis of variance (ANOVA) and ordinary least squares (OLS) do not take the multilevel nature of educational data into account and, when used, lend themselves to statistical difficulties such as deciding what unit of analysis to use – for example, the learner or the school (Lee, 2000). Statistical errors that are also encountered are aggregation bias, incorrectly estimated standard errors and heterogeneity of regression (Lee, 2000). More complex analysis techniques are required to account for the nested nature of the school data. These techniques are typically referred to as multilevel modelling and, specifically in this paper, Hierarchical Linear Modelling (HLM version 7.01)

software developed by (Raudenbush et al., 2013) has been used. Multilevel modelling is an extension of multiple regressions. However, regression produces a single equation and does not incorporate between-school differences.

Multilevel analysis, on the other hand, takes school differences into account and respects the heterogeneity of social data structures (Paterson & Goldstein, 1991). HLM allows for effects to be estimated at both the learner level and at the school level. By controlling for the home background factors, the study aims to isolate the different concepts of school climate that are associated with mathematics performance.

A two-level HLM model was created with learner-level variables serving as controls in level-1 and school and teacher variables added to the second level of the analysis. There are three basic, but very important stages to consider when designing a multilevel model.

The first step is the analysis of the unconditional (Null) model which provides information pertaining to the variance explained within and between schools. From the unconditional model, one is able to show whether the average school scores are significantly different and to determine the within-school variance in mathematics scores, as well as the between-school variance in achievement. Finally, the proportion of the variance explained between schools in relation to the total variance (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2004) is referred to as the intraclass correlation (ICC) and can be calculated as follows:

$$\frac{\hat{\tau}_{00}}{\hat{\tau}_{00} + \hat{\sigma}^2}$$

Where:

$\hat{\tau}_{00}$ = the estimated variance between schools;

$\hat{\sigma}^2$ = the estimated variance within schools

The ICC ranges from zero to one, with values closer to one being an indication of greater percentage of total variance between schools.

At the second stage, the level-1 (learner level) – also referred to as the random-coefficient model – is created. This model allows one to check which of the learner-level variables are significantly associated with mathematics achievement and these variables then also serve as controls in order to model the school/teacher effect.

Formally, there are $i = 1,.....n_j$ level-1 units (learners) which are nested within each of:

$j = 1,...j$ level-2 units (schools).

Level-1 model:

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{1j} + ... + \beta_{pj} X_{pj} + r_{ij}$$

Where:

β_{pj} $(p=0,1, ...p)$ are level-1 coefficients;

X_{pj} are level-1 predictors which are *learner age*, *gender*, *home socio-economic status* and whether a learner has experienced *bullying at school*;

$r_{ij} \sim N(0,\sigma^2)$ normally distributed with mean zero and variance σ^2 .

At the third stage, the level-2 model – also referred to as the intercepts-and-slopes-as-outcomes regression model – is created. In this model, each of the β_{pj} coefficients in the level-1 model becomes an outcome variable in the level-2 model

$$\beta_{qj} = \gamma_{q0} + \gamma_{q1} G_{1j} + \gamma_{q2} G_{2j} + \cdots \ldots\ldots\ldots\ldots + \gamma_{qSq} G_{Sq} + \mu_{qj} \; where \; \mu_{qj} \sim N(0, \tau_{00})$$

$$= \gamma_{q0} + \sum_{s=1}^{Sq} \gamma_{qs} G_{sj} + \mu_{qj}$$

Where:

γ_{qs} $(q = 0, 1, \ldots\ldots\ldots S^q)$= level-2 coefficients

G_{sj} = level-2 predictor

μ_{qj} = level-2 random effect

The results of the level-2 model can show whether the school level variables are significantly associated with average achievement and the proportion of the variance accounted for by the model.

The ICC calculated is based on the unconditional model before predictors are included. The variance calculated at level-2 is thus called conditional variance since the level-1 factors are controlled for. Therefore, the between-school variances at level-1 will be considered when calculating the variance explained at level-2.

The proportion of the variance explained by the final model is calculated as follows:

$$\frac{\hat{\tau}_{qq}(Level-1)-\hat{\tau}_{qq}(final\ Level-2)}{\hat{\tau}_{qq}(Level-1)}$$

Where:

$\hat{\tau}_{qq}(Level-1)$ = Estimated variance between schools at level-1

$\hat{\tau}_{qq}(final\ Level-2)$ = Estimated variance between schools at level-2

4.5 Results

4.5.1 Descriptive analysis

The descriptive analysis (Table 4.2) is focused on the bivariate relationships between the school climate factors and learner mathematics achievement. The school-level climate information was disaggregated to the learner-level data to make associations with learner achievement possible. The aim of this section is to see which of the school climate factors are positively or negatively associated with achievement. A full model that includes all the climate factors will be discussed in the next section.

In 2003, learners' being bullied explained most of the variance (27.59%) in mathematics achievement when compared to the other school climate components. The amount of variance it explains seems to decrease considerably in 2015 where it explains only 2.23% of the variance. The occurrence of bullying in schools is negatively correlated with mathematics achievement and the association becomes weaker from one cycle to the next with a Pearson correlation r = -0.53 in 2003 to r = -0.15 in 2015. Higher levels of bullying in schools are associated with lower mathematics scores but to a lesser degree in recent years.

Safe and orderly schools explained 7% of the variance in mathematics achievement in 2003; 3.18% in 2011 and 6.38% in 2015. It is positively correlated with achievement, but the variance that the scale explains differs drastically from one

cycle to another, with 2011 explaining the least amount of the variation between schools.

Discipline and safety has a very low association with mathematics achievement, but the variance explained increases over time from 1.5% in 2003 to 3.79% in 2015.

The emphasis teachers place on academic success is not correlated with mathematics achievement and, when compared with the other school climate indicators, explains the smallest portion of the variance.

School emphasis on academic success as reported by the principal has a higher association with achievement than the emphasis reported by the teacher, with r = 0.239 in 2003, r = 0.193 in 2011 and r = 0.203 in 2015. The variance explained is, on average, 4.51% across the three time points.

Table 4.2: Correlation and variance explained: school climate with mathematics achievement

	2003		2011		2015	
School climate dimensions	**Pearson Correlation**	**R^2 (%)**	**Pearson Correlation**	**R^2 (%)**	**Pearson Correlation**	**R^2 (%)**
Teacher emphasis on academic success	0.09	0.83	0.17	2.80	0.16	2.39
Safe and orderly	0.27	7.07	0.18	3.18	0.25	6.38
Discipline and safety	0.12	1.51	0.05	0.21	0.20	3.79
Learner bullying	-0.53	27.59	-0.24	5.53	-0.15	2.23
School emphasis on academic success	0.24	5.70	0.19	3.72	0.2	4.12

Source: TIMSS data (author's calculations)

4.5.2 HLM analysis

The results from the HLM analysis will be explained according to the three stages mentioned earlier.

4.5.2.1 **The unconditional model:**

The results provided in this section will respond to the first research question posed, focusing on the proportion of variance in mathematics achievement between schools. It is indicative of inequalities between schools and, the larger the intra-

class correlation coefficient or the closer the values is to one, the larger the inequality gap between schools.

At all three time points, a statistically significant variation was found in the mean mathematics scores between schools (Table 4.3) with p-values less than 0.001.

Table 4.3 shows an increase in the average mathematics performance in public schools from 288.94 in 2003 to 376.33 in 2015, an improvement of, on average, 87.4 points. The largest reduction (by 8%) in the variance between public schools was between 2003 (67%) and 2011 (59%). In 2015, 57% of the variance in average mathematics achievement occurs between schools, representing a reduction of 2% from 2011. Even though South Africa has seen a shift towards narrowing the inequalities between schools, 57% is still extremely high when compared to other upper-middle-income economies such as Tunisia which has an ICC of between 10 and 20 percent, Botswana (20 to 30 percent) and Chile with an ICC ranging from 30 to 40 percent (Zopluoglu, 2012).

Acknowledging that South Africa started from a very low base, it is clear that an improvement in average learner achievement has occurred from one cycle of TIMSS to the next. The education system has seen a substantial reduction in inequality between schools from 2003 to 2011. This extent of reduction was not maintained in 2015, however.

Table 4.3: HLM unconditional model results – Variance decomposition (2003, 2011, and 2015)

	2003	2011	2015
Average mathematics score	288.94	355.05	376.33
χ^2	6612.97	12425.01	13844.66
p-value	< 0.001	< 0.001	< 0.001
Total variance within schools ($\hat{\sigma}^2$)	3623.82	3237.25	3248.23
Total variance between schools ($\hat{\tau}^2$)	7287.32	4608.12	4231.82
ICC	0.67 = 67%	0.59 = 59%	0.57 = 57%
Reliability (λ)	0.971	0.980	0.978

Source: TIMSS data (author's calculations)

4.5.2.2 **The Level-1 (within-school) model:**

The results presented in this section (Table 4.4) will focus on the level-1 predictor variables selected (to serve as controls) and their association with mathematics achievement. The four variables considered were gender – specifically boys

(uncentered in the model); learner age (grand mean centered); bullying (group centered because the variable is one of the school climate factors and observation of between-school differences is important and also since it was aggregated and included in the school-level model as well); and home SES (grand mean centred).

Learner age is negatively associated with average mathematics performance, with older learners obtaining on average 10.14 points lower in 2003; 13.96 points lower in 2011 and 17.77 points lower in 2015 than younger, more grade age appropriate learners. Looking at the results, it appears the effect of overage learners has become more of a problem from one TIMSS cycle to the next. The relationship between age and performance varied significantly across schools in 2011 (χ^2 (279) = 411.01; p <0.001) and 2015 (χ^2 (284) = 437.31; p <0.001).

No gender difference in achievement is observed in 2003. However, a significant gender difference is observed in 2011, with boys scoring an average of 7.37 points higher than girls, as well as in 2015 where a 10.82 average score difference is observed between genders. When the other learner-level factors such as age, home SES and bullying are accounted for, a pro male gender achievement gap seems to emerge from 2003 to 2015.

The home SES measure was standardised with a mean of zero and standard deviation of one. In 2003, 2011 and 2015, home SES was significantly associated with average mathematics performance and, in all three cycles, the association varied significantly across schools (2003 (χ^2 (195) = 236.02; p =0.024); 2011 (χ^2 (279) = 367.39; p <0.001); 2015 (χ^2 (284) = 340.66; p =0.012). A one-point standard deviation increase in home SES is associated with an increase in the average mathematics achievement of 10.23 points in 2003; 5.67 points in 2011 and 4 points in 2015.

The occurrence of bullying within schools is negatively associated with average performance in all three cycles. However, the association with achievement seems to be reducing over time. Learners who attend schools where they are being bullied score on average 3.47 points, in 2003, lower than learners who attend schools where they are never bullied. The score difference seemed to have decreased by 2015 to

0.77. In 2011 the association between bullying and average performance varied significantly across schools (χ^2 (279) = 324.57; p =0.031). However, this was not the case in either 2003 or 2015.

Table 4.4: HLM Level-1 results (2003, 2011, 2015)

	2003	2011	2015
Fixed Effects			
Intercept	281.41***	347.16***	366.49***
Age	-10.14***	-13.96***	-17.77***
Boy	*Ns*	7.37**	10.82***
Home SES	10.23***	5.67***	4.00***
Bullying	-3.47***	-2.02***	-0.77*
Random Effects			
Intercept	1356.21**	2912.80***	4714.83***
Home SES slope	236.02*	367.39***	340.66*
Bullying slope	*Ns*	324.57*	*Ns*
Age slope	*Ns*	411.01***	437.31***

Source: TIMSS data (author's calculations)
Ns- p > 0.10; * p< 0.05; ** p< 0.01; *** p< 0.001;

4.5.2.3 **The Level-2 (school climate) model:**

The results presented in this section seek to respond to the following research questions:

- What are the school climate components that are associated with learner mathematics achievement in 2003, 2011 and 2015?
- How much of the variance between schools is explained by the school climate components?

Table 4.5 provides the multilevel results for each of the three cycles of TIMSS. Holding all other school climate components constant, learners who were taught by teachers who placed high emphasis on academic success scored, on average, 11.25 points higher than learners who were taught by teachers who did not place a high emphasis on academic success. This association was significant in 2011 only, with the p-value at less than 0.05.

The safe and orderly school component, when all other components are held constant, was significantly associated with learner mathematics performance in 2003, 2011 and 2015. A one-point increase in the safe and orderly component was

associated with, on average, a 4.07 point improvement in mathematics performance across 2003, 2011 and 2015.

Discipline and safety were significantly associated to mathematics only in 2003 and not in 2011 or 2015. Learners who attended schools where discipline and safety were not an issue scored, on average, 9.12 points higher than learners who attended schools with discipline and safety problems.

The school emphasis on academic success scale included a number of statements that the principal was required to respond to. This component was significantly associated with learner achievement only in 2015, with a score difference of 7.21 on average between learners attending schools where high emphasis was placed on academic success.

The bullying scale was a learner level variable that was aggregated to the school level and included in the analysis. Table 5 indicates that – across the three cycles, and with all others being held constant – this component showed the strongest significant negative association with learner achievement. Learners who attended schools where they said they were bullied was associated with lower levels of performance in schools with a score difference, on average, of 26.90 in 2003; 23.53 in 2011 and 23.75 in 2015. A clear indication that learners perform better when they attend schools with low or no incidence of bullying. However, since the study is cross-sectional in nature, causality cannot be assigned. It could also mean that higher-achieving learners attend schools where the incidence of bullying is lower.

Table 4.5: HLM Level-2 (school climate) results (2003, 2011, and 2015)

	2003	2011	2015
Fixed Effects			
Intercept (mean maths achievement)	284.54***	353.28***	364.07***
Teacher emphasis on math achievement	Ns	11.25**	Ns
Safe and orderly (teacher response)	4.76**	2.96*	4.50*
Discipline and safety (principal response)	9.12**	Ns	Ns
School emphasis on maths achievement	Ns	Ns	7.21*
Bullying (aggregated learner measure)	-26.90***	-23.53***	-23.75***
Random Effects			
Variance in school mean	2544.94	1815.69	1980.47
Variance in age	Ns	33.74	26.49
Variance in bullying	Ns	2.01	Ns
Variance in home SES slope	139.39	39.18	20.40
r_{ij}	3351.12	2942.87	2858.10

Source: TIMSS 2003, 2011 and 2015 data (author's calculations)
Ns- p > 0.10; * p< 0.05; ** p< 0.01; *** p< 0.001;

The third research question looks at the variance explained by the final model when the school climate components have been added.

The variance in school mean after controlling for the level-1 factors has decreased from 3985.28 in 2003 to 2544.94; from 2926.88 in 2011 to 1815.69 and, in 2015, from 2969.53 to 1980.47 (Table 4.6).

Table 4.6: Percent of variance explained between schools by the final model (2003, 2011, and 2015)

Year	Variance within schools (Level-1)	Variance between schools (Level-2)	Variance explained (Final Level-2 model)
2003	3985.28	2544.94	36
2011	2926.88	1815.69	38
2015	2969.53	1980.47	33

Source: TIMSS 2003, 2011 and 2015 data (author's calculations)

Thus, the school climate factors included in the model accounted for 36%, 38% and 33% in 2003, 2011 and 2015 of the total variance in mathematics scores respectively, an indication that these scores remained fairly consistent over time.

4.6 Discussion

The discussion that will follow will be done in response to the research questions stated earlier in the chapter.

4.6.1 Has the variance in learner achievement between public schools reduced from 2003 to 2015?

South Africa is an upper-middle-income economy but, to many, it embodies characteristics of both an industrialised and a developing country (McKeever, 2017) and it is still highly unequal as regards income. Education in South Africa is no different to other development indicators, with educational inequality being extremely high as is evident from the current results. Improvements are observed in the TIMSS average mathematics scores and a reduction in the variation or inequalities between schools from 67% in 2003 to 57% in 2015. Schools in South Africa also still remain highly unequal, with some of the highest recorded ICCs when compared to other, similar countries. Other upper-middle-income countries that also formed part of the TIMSS list of countries – such as Algeria, Latvia and Botswana – showed ICCs of less than 30%, a figure much lower than that of South Africa. Malaysia was the only other TIMSS country participant with an ICC similar to that of South Africa (Zopluoglu, 2012).

In an attempt to narrow the inequality gap between schools, a number of policies have been developed and implemented by the Department of Basic Education (Frempong et al., 2011). A large percentage of the national budget has been assigned to education so as to ensure that all previously disadvantaged schools are resourced (South African National Treasury, 2014).

4.6.2 How are selected learner contextual characteristics associated with learner mathematics achievement?

The current study followed a multilevel analysis methodology with learners at level-1 and schools at level-2. Even though the learner level served as controls in order to focus on the schools as the unit of analysis, some very interesting results have been observed and mention of these will be made within this section.

The appropriate average age of a Grade 9 learner is between 15 and 16 years. However, schools are faced with large numbers of overage learners in the system due to grade repetition or possibly due to their having started school late (Grissom, 2004). Research has shown that an association exists between age and learner achievement. This relationship is positive where learners are the appropriate age for the grade, moving towards negative the older the learner is (Grissom, 2004). This is true for the current study as well. However, of interest is the fact that the achievement gap has widened over time, an alarming development. The assumption could be that the retention policy that has been put in place is having an effect opposite to that intended. Research conducted by Battistin and Schizzerotto found that a learner retention policy must be followed and that it must include a plan for remedial education for learners who are retained (Battistin & Schizzerotto, 2012) because failure to do so would eventually result in school drop-out (Branson, Hofmeyr, & Lam, 2014).

In 2003, there was no significant gender gap with regard to mean mathematics achievement, however, the opposite was true in both 2011 and 2015. Boys obtained higher average achievement scores than girls and this performance difference is statistically significant after controlling for level-1 factors such as age, home SES and bullying. Research has found that, in the earlier primary years, girls have higher average achievement scores than boys. However, this phenomenon is reversed in the secondary schools (UNESCO, 2016).

The achievement gap between learners who are often bullied and those who reported never being bullied has reduced over time, which seems strange considering what is often reported in the media. It does however beg the question: Are the TIMSS measures of bullying a true reflection of the situation in South African secondary schools? The TIMSS indicators that measure bullying in schools refer to learners being made fun of, being left out of games and activities, having something stolen from them and so on. However, the school violence report published in 2012 refers to more severe cases of violence and brutality (Burton & Leoschut, 2013) that occur in school and this could mean that learners regard the TIMSS measures as part of daily life.

4.6.3 What are the school climate components that are associated with learner mathematics achievement in 2003, 2011 and 2015?

Five components of school climate, as defined by TIMSS, were included in the current study and each of these, for one or more TIMSS study cycles, was significantly associated with learner mathematics achievement. Learners being bullied at schools appears to be the component most significantly associated with achievement and the highest average score differences are observed between learners who say they are bullied regularly and those who are not often bullied. Bullying is also negatively associated with academic success, concurring with research previously carried out (Juvonen, 2007; Lillis & York, 2011; Strøm et al., 2013). However, the current study shows that this relationship has weakened over time. The reduced association between the bullying scale and learner performance over time does not necessarily mean that the levels of bullying in schools have reduced. It could mean that learners have been desensitised and perhaps do not consider certain behaviours as bullying. The two level HLM model looked at bullying between learners within the same school as well as bullying between schools. As earlier discussed, within the South African context differences from one school to the next explains the majority of the variation in academic achievement. Similarly the largest achievement differences with regard to bullying occurs from one school to another which could mean that how schools manage issues of bullying differs with some schools being more effective in their strategies than other schools. In 2003, the climate components most associated with academic achievement were a safe, orderly environment and discipline within schools within schools. Learners who attend schools where they feel safe and where discipline is not a problem perform well academically because, within such schools, a constant learning atmosphere is ensured (Melhuish et al., 2006). In 2015, however a slight shift in the school climate dynamic is observed with the emphasis that schools place on academic success being more significantly related to learner achievement. Within the TIMSS schools climate framework, this component is one of the dimensions of academic optimism which is linked to a positive atmosphere created within schools (Mullis et al., 2012). Its effect on academic success, however, is positive, but only if all stakeholders of a school (school management, teaching staff,

learners and parents) work collectively to implement arduous academic goals (Ekeh, 2014). It should be noted that TIMSS is a cross-sectional study and thus the relationship between school climate and achievement could be bi-directional. This would mean that it is also possible for parents of high achievers to send their children to schools with a climate more conducive to learning.

4.7 Conclusion

Even though the results across the three TIMSS cycles indicate a reduction in the inequalities between schools, the variance between schools in South Africa remains extremely high. Concerted plans need to be put in place to increase the rate at which the inequality gap is reduced. While the TIMSS school climate factors have had an effect on learner achievement, the effect that bullying has on learner achievement between schools seems, however, to stand out above the remaining factors. It is thus recommended that this area be unpacked so that the nature and extent of bullying can be better understood within the South African context. More so it eludes to policy issues beyond the school to the communities surrounding the school since the school is often a mirror image of the community that surrounds it. The Department of Basic Education, in an effort to reduce bullying and violence in schools, has implemented initiatives such as the National School Safety Framework as well as crime prevention programmes in cooperation with the South African Police to improve safety within schools. The implementation of these initiatives needs to be monitored and evaluated so that, where necessary, policies and implementation plans can be revised or developed to address the problems that learners are facing within schools. The findings from the study have shown that emphasis needs to shift from bullying prevention in schools to a school climate focus which would improve the atmosphere at schools and hence reduce bullying and violence occurring in schools. A deeper understanding of school climate in itself being considered as a "prevention plan" is of the utmost importance. The current study contributes to filling the methodological, conceptual and policy gaps. Methodologically, by applying a multilevel analysis which takes note of the hierarchical nature of educational system into account, the study was able to control for household characteristics, thus allowing the focus to be directed at the school. Conceptually, the TIMSS measures of school climate have been thoroughly

investigated, tested and improved upon over a number of years. Finally, the results allow for policy relevant dialogues to take place amongst key stakeholders and policy makers.

Chapter 5

5 Understanding the school climate and the socio-economic achievement gradient

5.1 Introduction

A global issue for many countries around the world is educational inequality which is directly associated with socio-economic disparity. It is common knowledge that learners from high-SES households attend academically advantaged schools with an abundance of resources and healthy school climates. The opposite is true for learners from low SES households.

A fair amount of literature has focused on school factors, such as human and physical resources, that could possibly reduce the SES effect (Marks, Cresswell, & Ainley, 2006; Mbugua & Muthaa, 2012; Spaull, 2012). A gap in the literature that focuses on school processes, like school climate, and its role in decreasing the SES effect does, however, exist. Thus, the main aim is to confirm, as with many studies, that a SES and achievement relationship exists, and to determine if school climate could assist in reducing the SES effect. In essence: Is it possible that having a positive school climate could aid in reducing the SES-achievement gap?

5.2 Literature review

5.2.1 Socio-economic status and learner achievement

Socio-economic status (SES) is a complex and often subjective concept measured in a number of different ways and is often referred to as multi-dimensional (Lim & Gemici, 2011; Taylor & Yu, 2009; Traynor & Raykov, 2013). It does not necessarily refer to the income of an individual or household only, but also includes scholastic qualification, material possessions, social status and social class to mention a few (Gustafsson, Nilsen, & Yang, 2016). In most school-based surveys, learners are asked to respond to a series of questions which give researchers a sense of the household's access to social, cultural and economic resources (Lim & Gemici, 2011). These, collectively, are then used to create the SES measure.

The SES and achievement relationship dates back to the 1960s and the Coleman Report which focused on educational inequalities (Coleman et al., 1966). The conclusion reached by Coleman and his colleagues was that SES explained more of the disparity in learner achievement than did the other variables considered in the study. Since then, researchers have discovered that a strong relationship exists between learner and school SES and learner achievement (Hernandez, 2014; Liu, Van Damme, Gielen, & Van Den Noortgate, 2015; Van der Berg, 2008). It has been found that learners from high-SES homes perform better than learners from low SES homes. One of the reasons for this is that learners in high-SES homes generally have parents who are better educated, are able to provide them with the necessary learning resources they require to succeed in school and are generally more involved in their children's education (OECD, 2009; Taylor & Yu, 2009). Reardon, in 2011, also showed that the achievement gap between learners from low SES households and those from high-SES households has widened over time (Reardon, Kalogrides, Katyn Chmielewski, Grewal, & Kasman, 2011).

The South African education system was highly unequal prior to 1994 and, since then, the National Education Department has attempted to address the historic differences with the intended purpose being to reduce the income inequality gap. Even though progress has been made, it has not been sufficient (Berkowitz, Moore, Astor, & Benbenishty, 2016; Van der Berg et al., 2011; Van der Berg, 2008). The country is thus faced with enormous SES inequities where the wealthy live in wealthier urban areas and their children have access to better-resourced schools which, ultimately, are linked to high academic achievement (Liu et al., 2015). The opposite is thus true for poorer households and the schools in these poor communities that learners have access to. Ideally, all schools in South Africa should be homogenous and learners should be able to attend any school and expect to receive education of the same quality. Unfortunately, this is not the case and SES as a factor still plays a large role in the schools that learners attend and thus has a large influence on academic success (May, 2006; van Ewijk & Sleegers, 2010).

5.2.2 School climate and learner achievement

An effective school is the ideal within any country and strides have been made towards obtaining a deeper understanding of educational effectiveness (Martin, Foy, Mullis, 2011; Scheerens, 2005; Uline et al., 1998). The general model of effectiveness involves "inputs" by educational departments in the form of resources into schools; "processes", which refers to the factors within a school that contribute to its functioning and, finally, "outputs" which is used to measure progress with the education system (Scheerens, 1990). Generally, learner academic performance is used as an output measure to inform the quality of education provided by the system.

School climate is one such factor that fits within the "process" section of the school effectiveness model (Astor, Benbenishty and Estrada, 2009; Cohen, McCabe, Michelli, & Pickeral, 2009; O'Brennan & Bradshaw, 2013) and its relationship with academic achievement will be the focus of this section.

Several scholars have various views on how school climate should be defined, but most agree that it refers to the social characteristics of a school (Lehr, 2010; Maxwell et al., 2017; Ruiz, 2016) as well as the relationships that exist between different sets of people such as the learners, their parents, their teachers and the school management (Cohen et al., 2009; O'Brennan & Bradshaw, 2013).

School climate is a multi-dimensional concept and is often referred to as the heart and soul of a school (Freiberg & Stein, 2003). A positive climate is open, healthy, warm and safe (Cohen, 2009; Hoy & Hannum, 1998; Lunenburg & Ornstein, 2009). School climate includes dimensions such as the emphasis schools place on academic success, the principals' involvement in leadership activities at the school, a safe and orderly environment, discipline and safety, and learners' sense of belonging, to mention a few (Mullis et al., 2012).

The school climate, linked to academic success, was investigated by scholars as early as the 1980's as part of their research into aspects of school effectiveness (Anderson, 1982; Purkey & Smith, 1983). These scholars found that processes that ensued within schools explained large amounts of the variation that occurred in

learner achievement beyond the learner's home factors (Purkey & Smith, 1983). It has been found that the strength of the effect of school climate on academic achievement is similar to that of SES (Brookover et al., 1978; R. Goddard et al., 2000; Thapa, Cohen, Guffey, & Higgins-D'Alessandro, 2013).

Schools with a positive climate are managed in a more holistic way, with learners who feel safe and supported (Voight, Austin, & Hanson, 2013), teachers are motivated and passionate about their professions (Raman, Chi Ling, & Khalid, 2015), and parents and community members are actively involved in the well-being and success of the school (Tschannen-Moran et al., 2006). This holistic approach to school climate may contribute to academic success. Unfortunately, the opposite is true for schools with an unhealthy school climate. Research has also revealed that schools with unhealthy climates are composed of learners with severe behaviour problems and are subject to high levels of school-based violence. Such schools are also located in high poverty communities marred by high levels of violence (Khoury-Kassabri et al., 2004). The section that follows will focus on the link between school climate, socio-economic status and academic achievement.

5.2.3 Interplay between school climate, socio-economic status and learner achievement

It has been noted earlier that South Africa still experiences large SES disparities and, unfortunately, SES is also strongly linked to academic achievement. In a very similar way, school climate has also been shown to have a very strong link to academic achievement. Is it possible that a link exists between school climate, SES and academic achievement? If so, what would this relationship be?

Scholars have found that open and healthy school climates are positively associated with academic success (Cohen & Geier, 2010), especially for learners from low SES households and communities (Eccles et al., 1993). Others have found that, when learners are provided with social support, this lessens the impact that SES has on learner achievement (Hopson & Lee, 2011). Some scholars, however, believe that school SES influences the school climate which, in turn, influences their academic achievement (McCoy, Roy, & Sirkman, 2013). Research has shown that

a positive school environment is vital for conducive learning and healthy development of learners (Hopson & Lee, 2011).

The school climate influence with regard to the SES-achievement dynamic is often explained using three terms, these are: compensating or additive; mediating; and moderating effects.

Compensating or additive effect:

Brand et al. (2003), believe that school climate has an additive effect on academic achievement and that this is greater in magnitude than the negative SES effect**.** The point to the compensation effect is that while SES and school climate are independent, both are associated with academic achievement and thus school climate adds to academic achievement beyond the SES effect (Berkowitz et al., 2015)(see Figure 5.1).

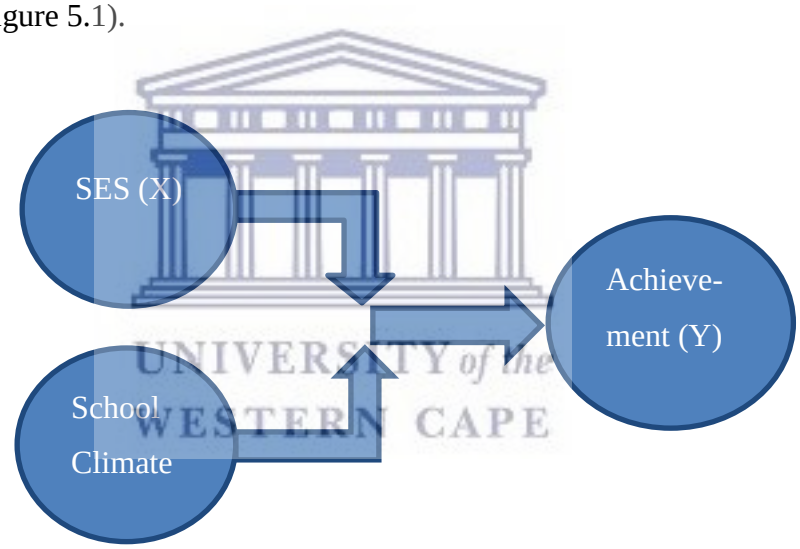

Figure 5.1: Graphical presentation of the compensating effect

Mediating effect:

The mediating effect speaks to causality, meaning that the independent variable causes the mediator variable which then causes the dependent variable (Holmbeck, 1997). Wang and Holcombe found that high-SES schools would have a healthier school climate which, in turn, would result in higher academic achievement (Wang & Holcombe, 2010) (see Figure 5.2). A mediator variable, on the other hand, establishes "how" or "why" a variable predicts or causes an outcome variable.

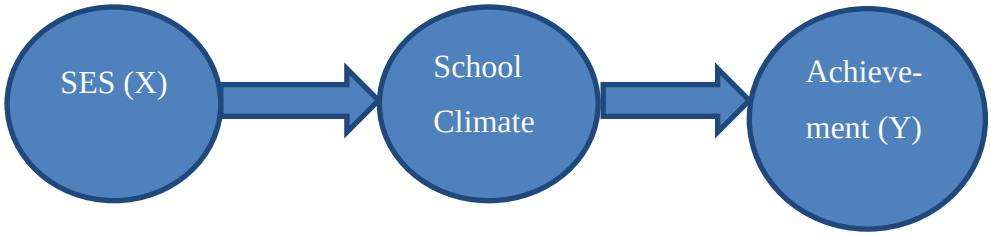

Figure 5.2: Graphical presentation of the mediating effect

Moderating effect:

A moderator variable is able to change the direction or strength of the relationship between an outcome and a predictor variable (Frazier, Tix, & Barron, 2004). Simply put, if school climate were to be included in a regression model as a moderator (Figure 5.3), there is a possibility that the association between SES and academic achievement would either become insignificant or would have reduced considerably (Ruiz, 2016). Within the multilevel context, it is also possible that this school climate-SES-achievement relationship would differ from one school to another (Cheema & Kitsantas, 2014).

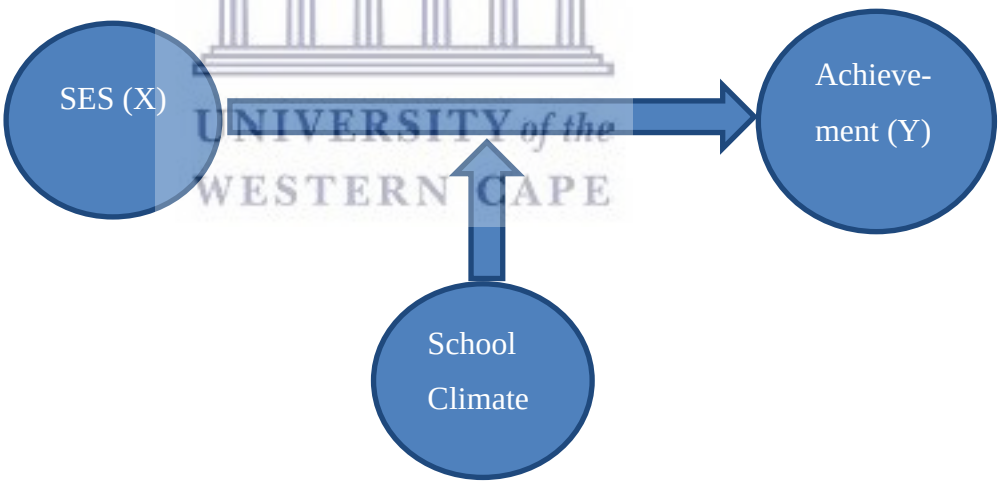

Figure 5.3: Graphical presentation of the moderating effect

5.3 Research questions

The main aim of the current paper is to confirm, as with many studies, that a relationship between SES and achievement exists, as well as to determine if school climate could assist in reducing the SES effect. This relationship will be tested by responding to the following research questions:

- To what extent does school climate compensate for the relationship between SES and academic achievement?
- To what extent does school climate moderate the relationship between SES and academic achievement?
- To what extent does school climate mediate the relationship between SES and academic achievement?

5.4 Methods

5.4.1 Data

Data for the current study were extracted from the TIMSS 2015 South Africa study conducted in August 2015. The study was administered to Grade 9 learners in a nationally representative sample which was selected using a two-stage stratified sampling design with schools drawn using a probability proportion-to-size (PPS) sampling method. The analysis for the current study will include 12 019 learners, 327 teachers and 292 school principals.

Since TIMSS is not a population-based study, various weights are calculated by the International Association for the Evaluation of Educational Achievement (IEA). The IEA encourages that weights be applied to data when analysis is performed. When a single-level regression analysis is performed, the learner weight is generally used, which is a combination of the learner sample weight, the class weight, the teacher weight as well as the school weight. However, for multilevel analysis, which is the methodology applied in the current analysis, the teacher weight was extracted from the IEA-created weight and this recalculated weight was used at the first level in the multilevel analysis (Rutkowski et al., 2010). Since the analysis includes learner mathematics scores, the accompanying mathematics teacher weight was applied at the second level of the analysis.

5.4.2 Handling missing data

The analysis undertaken in the current study is multilevel in nature and thus it is important that the treatment of missing data be dealt with by separating the school-level data from that of the learner-level data. At the school level, 2% of the cases at most had missing information with regard to the school climate measure (Table 5.1). Hence, mean substitution was used at this level.

Table 5.1: Number of missing cases at the school level

School Climate indicators	Valid	Missing	Mean
School emphasis on academic activities	326	1	9.7479638
Teacher emphasis on academic activities	322	5	9.6254877
Safe and orderly	324	3	9.1388916
Discipline and safety	322	5	8.4470021
Teacher job satisfaction	320	7	8.2275926
Challenges facing teachers	324	3	10.3169321
Learner sense of belonging	327	0	7.7367495
Bullying	327	0	7.3802713

Source: TIMSS 2015 data (author's calculations)

The only variable of concern at the learner level was parental education with almost 20% missing information. This is also a variable considered for inclusion when creating the home SES scale, so it was important that it be imputed. A bivariate analysis was performed first to establish the pattern of missingness.

Variables considered for the bivariate analysis included, number of books in the home, mathematics achievement, electronic devices in the home and the type of school the learner attended. These variables were selected because of their association with parental education. Research has shown that learners whose parents are higher qualified have more access to more resources in the home, attend high-SES schools and generally perform better than learners whose parents are less educated (van Ewijk & Sleegers, 2010).

The results of the bivariate analysis showed that the data is missing at random (MAR). Once the type of missingness was established, the next step was to determine whether the data showed an arbitrary or monotone missing data pattern. A Fully Conditional Specification (FCS) was used in the Multiple Imputation Procedure (Proc MI) and, since parental education was categorical in nature, a logistic procedure was used (Proc Logistic). The multiple imputation procedure was performed using the Statistical Analysis System (SAS) software and five imputed datasets were created and used when creating the home SES scale.

5.4.3 Measures

In addition to the learners' mathematics assessments, background questionnaires were administered to learners, principals and the mathematics educator teaching the sampled TIMSS class. Selected data from each of these questionnaires was extracted and included in the analysis. Using ConQuest (Adams, Wu, & Wilson, 2015), an Item Response Theory (IRT) software package, a number of composite scales were created. The details of the outcome or dependent variable as well as the scales created are provided as follows:

5.4.3.1 Outcome variable

TIMSS administers a mathematics and science assessment to learners included in the sample. For the purposes of the current analysis only, the mathematics assessment scores will be included since research shows that the results obtained by learners for these two subjects are highly correlated (Wang & Ma, 2016), meaning that learners who do well in mathematics also do well in science and vice versa.

Five plausible values are calculated for each learner using IRT. TIMSS includes a vast number of mathematics items and learner fatigue would set in if learners were expected to respond to all items. To prevent this, learners were tested on only a portion of the total TIMSS items available and, so as to ensure that a total score could be assigned, IRT was used to calculate five estimates for each learner. Certain background factors were taken into account when these estimates were calculated. These five plausible values were included in the analysis and served as the dependent variable. The details pertaining to the IRT methodology implemented by the IEA can be found in the detailed Methods and Procedures document (Martin, Mullis, & Hooper, 2015)

5.4.3.2 Socio-economic status (SES)

In general, home SES is measured in a number of ways by various researchers and is often referred to as being multi-dimensional (Lim & Gemici, 2011). Some of the dimensions include resources in the home, parental education, family structure and economic contributions in the form of parental salaries (Taylor & Yu, 2009). However, one is often confined to what is available in the dataset being used. Since

the TIMSS data is used for the analysis in this study, the variables considered in creating the SES indicator focused on resource availability in the home, family structure and parental education. Table 5.2 provides the list and types of variables considered for the analysis.

Table 5.2: Variables considered for inclusion in the SES measure

Variable Name	Variable Label	Variable type	# Categories	Included?
NumBooks	Number of books in the home	Ordinal	3	-
ICT_HME	Number of digital devices in the home	Ordinal	4	√
ParEduc1	Highest Parental education	Ordinal	3	-
Famstruc	Two-parent household vs other	Binary	2	-
Q6a	Do you have a computer tablet of your own	Binary	2	√
Q6b	Do you have a computer tablet shared?	Binary	2	-
Q6c	Do you have a study desk?	Binary	2	√
Q6d	Do you have your own room?	Binary	2	√
Q6e	Do you have an internet connection?	Binary	2	√
Q6f	Do you have your own mobile phone?	Binary	2	√
Q6g	Do you have a gaming system?	Binary	2	√
Q6h	Do you have a dictionary?	Binary	2	√
Q6i	Do you have electricity?	Binary	2	√
Q6j	Do you have running tap water?	Binary	2	√
Q6k	Do you have a television?	Binary	2	√
Q6l	Do you have a DVD player?	Binary	2	√
Q6m	Do you have water flushed toilets?	Binary	2	√
Q6n	Do you have a motor car?	Binary	2	√
Q6o	Do you have a landline telephone?	Binary	2	√
Q6p	Do you have a fridge?	Binary	2	√

The IRT procedure in SAS was utilised to create the SES indicator since the variables included in the construct were either ordinal or binary. A normal factor analysis procedure was not an appropriate method since such a procedure relies on all variables being continuous. A total of 20 items were considered for the SES scale and hence a set of 20 eigenvalues was created by the IRT procedure. Since the first eigenvalue was considerably larger, however, only one factor was retained for the SES measure. The factor explained 42% of the variance. The IRT output includes an estimate of the slope parameter for each of the variables included. If the estimate was less than 0.5, the variable was excluded from the final SES construct. The last column of Table 5.2 provides an indication of the variables that remained as part of the scale. For ease of interpretation, the SES measure was standardised to a mean of zero and standard deviation of one. Figure 5.4 provides the scree plot, which plots the factors against the eigenvalues and well as the proportion of variance

explained by each of the factors. The graph shows that, after the first component, the graph flattens.

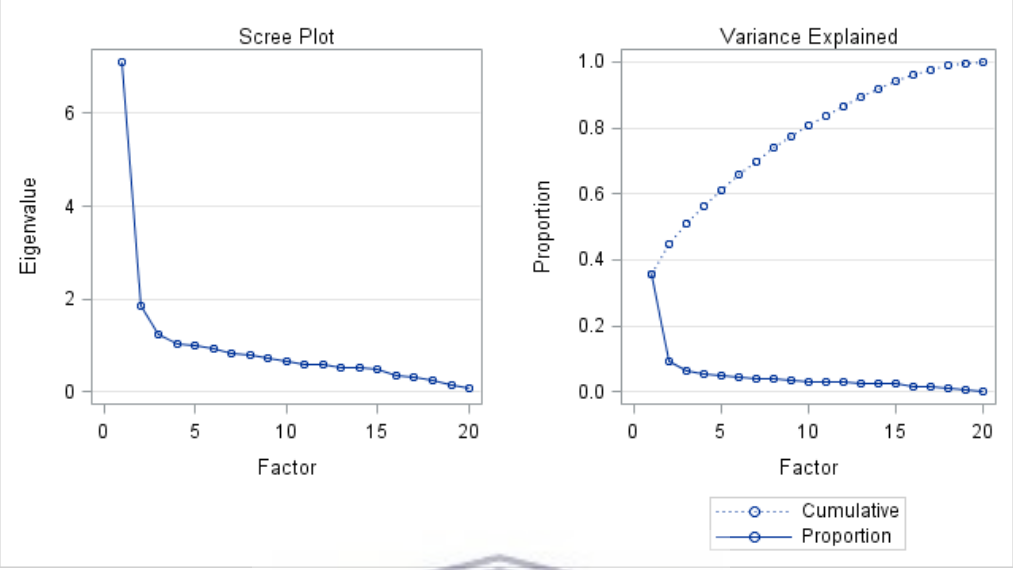

Figure 5.4: Scree plot and variance explained by the eigenvalues

5.4.3.3 School climate measures

The school climate framework used by TIMSS was extended in 2015 to include additional measures that the IEA found to be linked to school climate. Thus, eight school climate constructs were included as part of the analysis. These constructs were created using the ConQuest IRT package (Adams et al., 2015) and adhering to the strict guidelines provided by the IEA (Martin et al., 2015). The school climate scales included in the analysis were continuous scales and, for consistency with the TIMSS methodology, these scales were not standardised. Details pertaining to the statements included in each of the scales can be found in Appendix 5.2. The statements included in each of the constructs were in the form of Likert scales which were recoded so that high values on the scales corresponded to positive responses to the statements.

Emphasis placed on academic success consisted of 13 statements that the school principal and 14 statements that the mathematics teacher responded to respectively. The additional statement in the teacher instrument asked about collaboration between leadership and teachers. The set of statements took the form of a Likert scale and response options were “very low” (coded as 1), “low” coded as 2, “medium” coded as 3, “high” coded as 4 and “very high” (coded as 5).

The **Safe and orderly school** section included a set of 8 statements that teachers were asked to respond to. The response options were “agree a lot” coded as 1, “agree a little” coded as 2, “disagree a little” coded as 3 and “ “agree a lot” coded as 4.

School discipline problems included 11 statements that the principal of the sampled school was asked to respond to. Principals were asked the degree to which each of the listed statements was a problem in schools. The responses took the form of a Likert scale with response options, “not a problem” coded as 1, “minor problem” coded as 2, “moderate problem” coded as 3 and finally “serious problem” coded as a 4.

The **Teacher job satisfaction** construct was based on seven statements that asked teachers about their profession, their enjoyment and satisfaction with being employed at the schools. The responses took the form of a Likert scale with 3 options; “not at all’ coded as 1, “some” coded as 2 and “a lot” coded as 3.

Challenges facing teachers included a set of eight statements asking teachers what some of the challenges are that they face when at school. The response options were “agree a lot” coded as 1, “agree a little” coded as 2, “disagree a little” coded as 3 and “agree a lot” coded as 4..

The **Sense of belonging** scale included a set of seven statements that asked the learners how they felt about their school. The response options were “agree a lot” coded as 1, “agree a little” coded as 2, “disagree a little” coded as 3 and “agree a lot” coded as 4.

The **Learner bullying** scale included nine statements that asked how often learners experienced various aspects of bullying while at school. The original response options were “at least once a week” coded as 1 , “once or twice a month” coded as 2, “a few times a year” coded a 3 and “never” coded as 4. The original scale was recoded to 1 if a learner had never experienced instances of bullying and 2 if a learner had. The effect of this was that codes 2 through 4 were recoded as 2.

Since the focus of the study is on school climate factors at the school level, the learner sense of belonging and the bullying scales were aggregated to the school level for inclusion in the multilevel analysis that is explained later in the paper.

5.4.4 Data analysis plan

A multilevel analysis was performed using the Hierarchical Linear Modelling (HLM) version 7.01 developed by Raudenbush and co-researchers (Raudenbush et al., 2013). This methodology made sense since educational systems are hierarchical in nature and, in general, learners are nested in classrooms, classrooms within schools and schools within provinces. A two-level analysis was run with learner-level variables at the first level and school climate variables at the second level. Adding the school climate variables at the school level made sense because it refers to the experiences of learners, teachers and school management within a particular school. Since the school climate variables (level-2 variables) and their association with SES are the focus of the current paper, the level-1 variables included serve as controls and will be reported on as part of the results but is not the focus of the paper.

A series of models were run. The first of these is referred to as the unconditional model and comprised no predictor variables, provided an indication of the variance between and within schools, and also justified the use of multilevel modelling as the appropriate method. The higher the variance between schools, the higher the inequality, thus necessitating the use of HLM as an analytical technique.

Unconditional model:

There are $i = 1,.....n_j$ level-1 units (learners) nested within each of $j = 1,...j$ level-2 units (schools).

$$Y_{ij} = \beta_{0j} + r_{ij} \qquad (1)$$

$$\beta_{0j} = \gamma_{00} + \mu_{0j} \qquad (2)$$

$$Y_{ij} = \gamma_{00} + \mu_{0j} + r_{ij} \qquad \text{Substitute (2) into (1)}$$

$$Var(Y_{ij}) = Var(\gamma_{00}) + Var(\mu_{0j}) + Var(r_{ij})$$

Total Variance = Within-School Variance + Between-School Variance.

All the learner variables were then added at level-1 and only the significant variables were retained in the final level-1 model. The models that followed the level-1 model tested the compensatory, moderating and mediating effects, as discussed in the literature review. The basic HLM model was provided in Section 4.4.6.2 (page 64) and the details pertaining to each of the effects are shown in the results section below.

All level-1 and level-2 variables were centred around the grand mean with the exception of gender which was dichotomised and hence uncentered with fixed slopes. The home SES variable at level-1 was group centred and the slope was allowed to vary since it is assumed that SES will vary significantly from one school to another.

5.5 Results

An explanation of the sample with reference to the mean, standard deviation and range will be provided first (Table 5.3). This will be followed by the interpretation of the HLM results of the compensating, moderating and mediating effects.

5.5.1 Sample description

The sample included 12 156 learners, 327 teachers and 292 schools. Girls made up 51% and boys made up 49% of the sample. Learners' age range was between 13 and 18, with an average age of 15.8 which is slightly higher than the 15.2 which is the average age a learner should be in Grade 9. Both age and square of age were included at level-1 in the event that the age-achievement relationship was not linear. Age square was retained in the model since age became insignificant when the square term was included; meaning that the relationship is not necessarily linear in nature.

The bullying scale had a mean of 7.48 and a standard deviation of 2.89. Learner sense of belonging had a mean of 7.76 and a standard deviation of 1.43. Learner home SES was standardised to a mean of zero and a standard deviation of one. The maximum mathematics score achieved was 732.33 with a minimum value of 124.49, providing an average of 372 points and standard deviation of 82.43

On average, 7 out of 10 (std dev =2.89) learners had experienced incidents of bullying in schools. The learner sense of belonging scale ranged from a minimum of 6.4 to a maximum of 10.2 with a mean of 7.74 and a standard deviation of 1.43, which implies that most learners felt like they belong at the school they attended. Teachers were asked about the challenges they experience at school; the scale ranged from very low (few challenges) to very high (many challenges). The average on this scale was 10.32 with a standard deviation of 1.69 and a range of 15.53. Both principals and teachers were asked about the emphasis that they place on academic success. For both the scales ranged from approximately 5.4 to 17.1 with an average of 9.6 and 9.8 for teachers and principals respectively. School safety and orderliness ranged from not safe, with a minimum of 4.9, to very safe, with a maximum of 13.7, a mean of 9.1 and a standard deviation of 1.82. The school discipline scale ranged from few discipline problems with a minimum value of 2.2 to many discipline problem (maximum = 13.9) and a mean and standard deviation of 8.5 and 1.82 respectively, meaning that schools are faced with many discipline problems.

Table 5.3: Descriptive analyses of the level-1 and level-2 variables included in the model

Level-1							
Variable Name	**Variable label**	**Variable direction**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
BSMMAT01	Maths score	Lowest to Highest	12156	372.23	82.43	124.49	732.33
GIRL	Gender: Girl	Dichotomised (1) Girl, (0) Otherwise	12156	0.51	0.5	0	1
BSDAGE	Learner age	Lowest to highest	12156	15.75	1.25	10	20
AGESQ	Learner age	Lowest to highest age	12156	248.67	39.05	100	396.81
BULLYING	Extent to which learners are bullied	Low levels to high levels of bullying	12156	7.48	2.89	1.99	14.33
SENSEBEL	Learner sense of belonging	Little to high sense of belonging	12156	7.76	1.43	2.1	10.21
ZSES_IRT	Home socio-economic status (standardised to mean=0 and Std Dev=1)	Low SES to high SES	12156	0.03	0.98	-2.88	2.14
Level-2							
Variable Name	**Variable Label**	**Variable Direction**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
BULLYING	Bullying: aggregated from the learner level	Low levels to high Levels of bullying	327	7.38	1.02	1.99	10.34
SCHBEL	Sense of belonging: aggregated from the learner level	Little to high sense of belonging	327	7.74	0.54	6.4	10.21
TCHCHAL	Challenges that teachers face	Few challenges to many challenges	327	10.32	1.69	2.09	17.62
TCHSAFE	Safe and orderly school	Not safe to very safe	327	9.14	1.82	4.9	13.66
TCHEMPH	Teacher emphasis on academic success	Low emphasis to high emphasis	327	9.63	1.91	5.44	17.14
TCHJBSAT	Teacher job satisfaction	Not satisfied to very satisfied	327	8.23	1.96	2.17	10.78
SCHEMPH	School emphasis on academic success	Low emphasis to high emphasis	327	9.75	1.64	6.46	15.89
DISCIPLI	School discipline problems	Few discipline problems to many discipline problems	327	8.45	1.82	2.22	13.85
ZSCH_SES	SES: Aggregated from the learner level (standardised to mean=0 and Std Dev=1)	Low SES to high SES	327	0.12	0.72	-1.91	2.14

5.5.2 HLM analysis

The results from the HLM analysis will be explained as follows:

1. The unconditional model;
2. Level-1 model;
3. Compensating (additive) effect;
4. Moderating effect; and
5. Mediating effect.

5.5.2.1 The unconditional model

Table 5.4 provides the results of the unconditional model void of predictors. The results from this model provide the motivation for the use of multilevel analysis. Total variance is divided into between-school and within-school variance with between-school variances greater that 10% warranting the use of multilevel analysis. The between-school variance in the current analysis is 61% which means that only 39% of the variance is explained between learners within schools.

Table 5.4: HLM unconditional model results – variance decomposition

Average mathematics score	385.2
χ^2	17075.60
p-value	< 0.001
Total variance within schools ($\hat{\sigma}^2$)	3197.72
Total variance between schools ($\hat{\tau}^2$)	5051.23
ICC	0.61 = 61%
Reliability (λ)	0.98

Source: TIMSS 2015 data (author's own calculations)

5.5.2.2 Level-1 (within-school) model:

The level-1 model used in the analysis was as follows:

$$BSMMAT01_{ij}=\beta_{0j}+\beta_{1j}*(AGESQ_{ij}) +\beta_{2j}*(BULLYING_{ij}) +\beta_{3j}*(SENSEBEL_{ij}) +\beta_{4j}*(ZSES\_IRT_{ij}) + r_{ij}$$

The variables selected as controls for the analysis were all significantly related to learner mathematics achievement (Table 5.5). The strongest associations with mean achievement were home SES and learner sense of belonging. Learners who felt like they belonged at the school scored 2.31 points higher, on average, than learners who felt they did not belong at the school.

Home SES was standardised to a mean of zero and a standard deviation of one. The results show a positive association between average achievement and home SES, with learners from high-SES backgrounds performing better than learners from low SES homes. A one standard deviation increase in home SES is associated with an increase in the average mathematics achievement of 2.65 points.

Bullying is negatively associated with learner achievement, meaning that learners who said they were bullied obtained lower average scores than learners who were never bullied.

Table 5.5: HLM level-1 results

	Level-1
Fixed Effects	
Intercept	384.23***
AGESQ – Age	-0.46***
ZSES_IRT - Home SES	2.65*
SENSEBEL - Sense of belonging	2.31*
BULLYING – Bullying	-0.88**
Random Effects	χ^2
Intercept	16101.79***
Home SES slope	0.050*

Source: TIMSS 2015 data (author's calculations)
* p< 0.05; ** p< 0.01; *** p< 0.001;

5.5.2.3 Compensating or additive effect:

In this model it is hypothesised that school climate plays an additive role to achievement beyond SES. To test the additive effect, two models were run. The first model included only the SES variable, and in the second model, the school climate factors were added to the first model. The model used when testing the compensating effect was as follows:

Level-2 Model

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(BULLYINGj) + \gamma_{02}*(SCHBELj) + \gamma_{03}*(TCHCHALj) + \gamma_{04}*(TCHSAFEj) + \gamma_{05}*(TCHEMPHj) + \gamma_{06}*(TCHJBSATj) + \gamma_{07}*(SCHEMPHj) + \gamma_{08}*(DISCIPLIj) + \gamma_{09}*(ZSCH\_SESj) + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40} + u_{4j}$$

Only the significant factors were included in the final model and will form part of the interpretation (Table 5.7).

Socio-economic status was positively associated with average mathematics achievement, with learners from high-SES homes scoring 66.86 points higher than learners from low SES households. When the school climate variables are included in the model, the score difference between learners from high and low SES households dropped to 50.5 score points. This shows that school climate has a compensating effect over and above the SES association.

Bullying is negatively associated with achievement, meaning that learners who attended schools with a high concentration of bullying often scored, on average, 11.49 points lower than learners who attended schools where bullying was not a problem. Table 5.6 provides the list of statements included in the bullying scale as well as the percentage of learners who said yes to each of the statements. Predominantly learners said that learners either stole from them, made fun of them or spread lies about them.

Table 5.6: Percentage of learners who responded to each statement included in the bullying scale

Types of bullying in the questionnaire	
Stole something from me	71
Made fun of me or called me names	62
Spread lies about me	52
Left out of their games and activities	42
Shared embarrassing Information About me	40
Threatened me	35
Hit Or Hurt me	33
Made me do things I did not want to do	29
Posted embarrassing things about me online	19

The emphasis that a school places on academic success is positively associated with average achievement. Learners attending schools that place a high emphasis on academic success score on average 7.75 points higher than learners who attend schools where little emphasis is placed on academic success.

Challenges that teachers face are negatively associated with achievement with a score difference of 3.47 between learners who are taught by teachers faced with many challenges and those who are not.

Learners who are taught by teachers who perceived the school to be safe scored on average 4.65 points more than their counterparts.

Table 5.7: Results of the compensation effect

	Model 1	**Model 2**
Fixed Effects		
Intercept (mean math achievement)	384.17***	382.31
ZSCH_SES – Socio-economic status (aggregated learner measure)	66.86***	50.51***
TCHEMPH – Teacher emphasis on math achievement		Ns
TCHSAFE – Safe and orderly (Teacher response)		4.65***
DISCIPLI – Discipline in schools (Principal Response)		Ns
SCHEMPH – School emphasis on math achievement		7.75***
BULLYING – Bullying (aggregated learner measure)		-11.49***
TCHJBSAT – Teacher job satisfaction		Ns
TCHCHAL – Challenges facing teachers		-3.47**
SCHBEL – Learner sense of belonging (aggregated learner measure)		Ns
Random Effects	67	
Variance in school mean	1411.19	1005.28
Variance in Home SES slope	16.23	16.17
r_{ij}	2875.02	2875.83

Source: TIMSS 2015 data (author's calculations)
Ns – p > 0.10; * p< 0.05; ** p< 0.01; *** p< 0.001;

The variance depicted in Figure 5.5 is the variance explained by the models. SES, in itself, explains 51% of the variance in learner achievement score. With the school climate variables added to the model, an additional 14% of variance is explained and this proves that school climate has a compensatory effect on achievement.

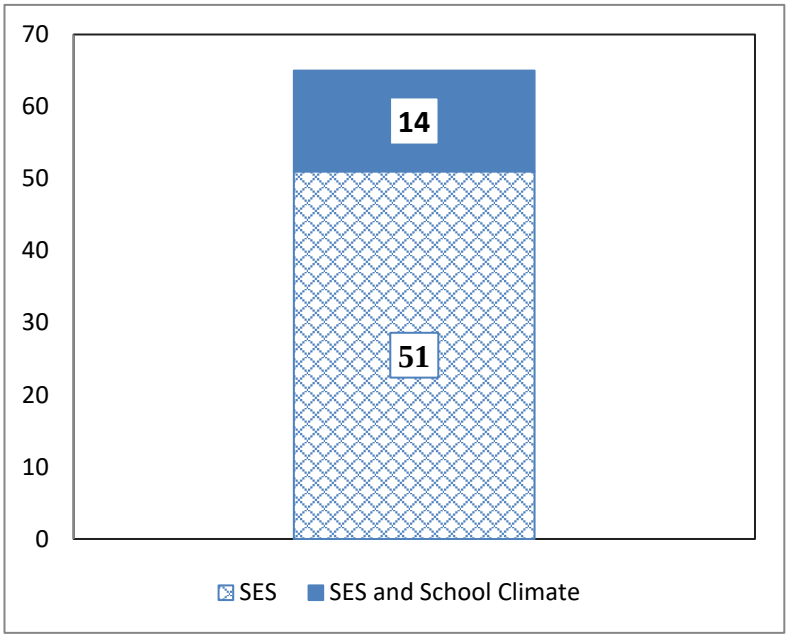

Figure 5.5: Results of the compensation effect

5.5.2.4 Moderating effect

School climate changes from one school to another; some are healthy and some are not. With the moderating effect, the aim is to hypothesise that the association between SES and achievement changes depending on the school climate of the particular school.

A slopes-as-outcomes model was used to test the moderating effect as follows:

Level-2 model

$\beta_{0j} = \gamma_{00} + \gamma_{01}*(BULLYINGj) + \gamma_{02}*(TCHCHALj) + \gamma_{03}*(TCHSAFEj) + \gamma_{04}*(SCHEMPHj)$
$+ \gamma_{05}*(SCH\_SESj) + r_{0j}$
$\beta_{1j} = \gamma_{10}$
$\beta_{2j} = \gamma_{20}$
$\beta_{3j} = \gamma_{30}$
$\beta_{4j} = \gamma_{40} + \gamma_{41}*(BULLYINGj) + \gamma_{42}*(SCHBELj) + \gamma_{43}*(TCHCHALj) + \gamma_{44}*(TCHSAFEj)$
$+ \gamma_{45}*(TCHEMPHj) + \gamma_{46}*(TCHJBSATj) + \gamma_{47}*(SCHEMPHj) + \gamma_{48}*(DISCIPLIj)$
$+ u4j$

The results showed that the SES-school climate interaction was not significant and hence that school climate does not moderate the association between SES and achievement (see Table 5.8).

Table 5.8: Results of the moderation effect

Fixed Effects	**Coefficient**
For SES slope (β_{4j})	
Intercept (γ_{40})	2.63
TCHEMPH – Teacher emphasis on maths achievement	0.72 (*Ns)*
TCHSAFE – Safe and orderly (Teacher response)	-0.92 (*Ns)*
DISCIPLI – Discipline in schools (Principal Response)	0.40 (*Ns)*
SCHEMPH – School emphasis on math achievement	-0.01 (*Ns)*
BULLYING – Bullying (aggregated learner measure)	-0.77 (*Ns)*
TCHJBSAT – Teacher job satisfaction	0.66 (*Ns)*
TCHCHAL – Challenges facing teachers	-0.41 (*Ns)*
SCHBEL – Learner sense of belonging (aggregated learner measure)	-1.70 (*Ns)*
Random Effects	
Variance in school mean	1005.23
Variance in Home SES slope	11.05 (*Ns)*
r_{ij}	2875.42

Source: TIMSS 2015 data (author's calculations)
Ns – p > 0.10; * p< 0.05; ** p< 0.01; *** p< 0.001;

5.5.2.5 **Mediating effect**

It is hypothesised that SES influences school climate which, in turn, influences achievement. SPSS was used to test the assumption using an add-on called Process (Hayes, 2012), which allows for testing mediation at the school level. SES was the independent variable, mathematics achievement, the dependent variable and each of the school climate variables served as the mediator variables.

The first step is to test the direct relationships between SES and achievement as well as school climate and achievement. If significant associations exist, then the indirect associations are tested with school climate, SES and achievement (Figure 5.6). The results show that the total effect, which is the association between SES and achievement (path c), is significant (R^2 =0.25, β = 27.5, p-value < 0.001) and thus further tests investigating the mediating effects of school climate are justified (Table 5.7).

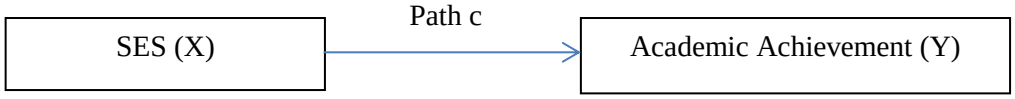

Figure 5.6: Direct effects

Figure 5.7 provides the graphical representation of the mediating effects. All the school climate variables were included in the analyses, but the final analysis includes only the significant factors as shown in the figure. The final model provided the test for a four-path mediated effect (Preacher & Hayes, 2008) which allows for the testing of relationships between SES and each of the mediators, the mediators to achievement as well as the indirect relationships between SES-Mediators-Achievement.

The direct effect, which is the association between SES and achievement after controlling for the mediator variables, is significantly associated ($\beta = 22.2$, p-value < 0.001).

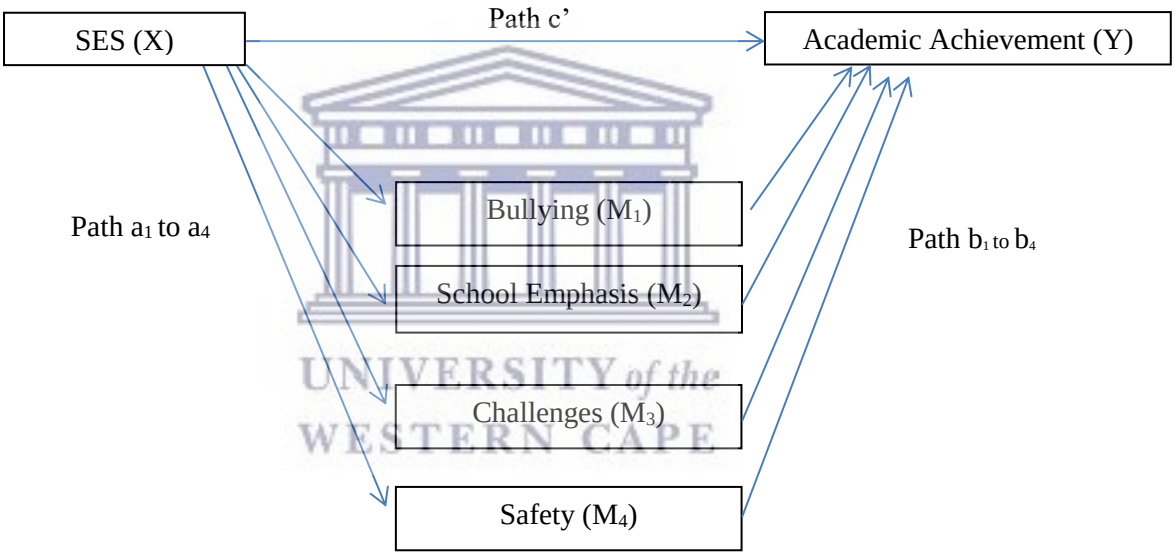

Figure 5.7: Indirect mediator effect

Previously, the Sobel test was used. However, it has been found to be overly conservative and it assumes independence which, in the case of multilevel modelling, is not true (David, 2016). Confidence intervals were created using bootstrapping to estimate and test the significance of the indirect effects. Bootstrapping is non-parametric and is based on a resampling methodology with replacement when estimation is done (David, 2016). For the current analysis, resampling was done a total of 5 000 times. The confidence intervals (CI) play an important role in interpreting the indirect effects (Predictor-Mediator-Outcome). If

a zero is included in the CI, the indirect effect is not significant (Preacher & Hayes, 2004). The results included in Table 5.9 are for significant mediating effects only.

The incidence of bullying and the challenges that teachers face are significant mediators of the relationship between SES and achievement (β = 0.56, SE=0.08). Learners from high-SES homes are less likely to be bullied and are more likely to be taught by teachers who are faced with fewer school challenges.

Learners from high-SES homes more often than not attend schools that are not faced with issues of safety (β = 0.51, SE=0.11) and this places emphasis on academic success (β = 1.33, SE=0.16).

Table 5.9: Results of the direct and indirect mediator effects

	Path coefficient					Indirect effects	
Dependent / Independent	**Achievement (Y)**	**to bullying (M1)**	**to school emphasis (M2)**	**to challenges (M3)**	**to safety (M4)**	**Estimate**	**Bias-Corrected Bootstrap 95% CI**
SES (X) (path – c')	22.2 (0.65)	-0.26 (0.03)	0.18 (0.01)	-0.28 (0.02)	0.08 (0.02)		
Bullying (M1)	-2.19 (0.21)		0.01 (0.004)	0.02 (0.01)	-0.01 (0.01)		
School emphasis (M2)	7.25 (0.49)						
Challenges (M3)	-6.35 (0.38)		-0.11 (0.01)		-0.004 (0.0004)		
Safety (M4)	6.08 (0.41)		0.24 (0.01)				
Total (path – c)	27.50 (0.67)						
X →M1→Y						0.56 (0.08)	(0.41, 0.74)
X →M2→Y						1.33 (0.16)	(1.03, 1.65)
X →M3→Y						1.80 (0.14)	(1.53, 2.10)
X →M4→Y						0.51 (0.11)	(0.30, 0.74)

Source: TIMSS 2015 data (author's calculations)
Ns – p > 0.10; * p< 0.05; ** p< 0.01; *** p< 0.001;

5.6 Discussion

In a country like South Africa, marred by high inequalities as referenced by a 0.6 GINI coefficient (UNDP Regional Bureau for Africa, 2017), academic achievement and SES gaps are of grave concern. This is confirmed by the results of the current study as well as by between-school variations in South Africa being 61%, a figure that is extremely high when compared to other upper-middle income countries such as Botswana and Tunisia with ICC's of 30% and 20% respectively (Zopluoglu, 2012). Finding mechanisms to narrow the inequality gaps is high on the agenda of the Department of Basic Education (Taylor et al., 2011). The results have shown that SES is significantly associated with learner mathematics achievement and that it explains 51% of the variance in learner achievement. This SES-Achievement association is in line with research previously done – as early as the Coleman Report in 1966 and decades later as well (Coleman et al., 1966; Hernandez, 2014; Reardon et al., 2011; Ruiz, 2016; Van der Berg, 2008).

Learners from high-SES homes scored on average 67 points more than learners from lower SES homes, which is in line with findings published by Frempong and his co-authors (Frempong et al., 2011) showing large achievements gaps between various SES levels. Parents with access to more financial resources are able to send their children to better quality schools with a proven record of high performance. Unfortunately for low SES households, school choice is limited and parents need to send their children to the closest school, irrespective of the quality of education provided by that school.

As with SES, school climate has also been shown to be significantly associated with learner achievement, with research in this area dating back to the 1980s within the realm of school effectiveness research (Anderson, 1982; Purkey & Smith, 1983; Ruiz, 2016). Four of the eight school climate factors were significantly associated with mathematics achievement. Learners who attended schools that were safe and orderly, and that placed a high emphasis on academic success, obtained higher scores than learners who attended schools that were not safe. The finding is in line with research conducted by Van der Westhuizen and his co-authors who found that,

in well-performing schools, the atmosphere was orderly, well-disciplined and safe (Osher et al., 2012; Van der Westhuizen et al., 2005).

The independent effects of SES and school climate on learner achievement have been discussed and seem to be in line with what research has found. The main aim of the current paper, however, was to determine the role that school climate plays in trying to understand the SES-learner achievement relationship, since research has found that school climate is positively associated with achievement, especially in high poverty communities (Cohen & Geier, 2010; Eccles et al., 1993). Three scenarios were tested to determine whether school climate compensates, moderates or mediates the relationship between SES and learner achievement.

The idea behind the compensating effect is that school climate improves the probability of positive learner achievement over and above the SES effect (Brand et al., 2003; Hopson & Lee, 2011). The results show that school climate explains an additional 14% of the variation in learner achievement scores over and above the 51% explained by SES. In addition, by adding the school climate to the model, the SES-achievement gap dropped by 17 score points on average. This is in line with previous research which suggests that school climate is positively associated with achievement beyond the negative effect that coming from a low SES background has on achievement (Gregory & Weinstein, 2004). It is clear – and has been proven – that SES is still one of the highest contributing factors to academic success. What the results of the compensation model have, however, shown is that school climate can make a difference regardless of the home environment that the learner comes from (Cohen et al., 2009).

A moderator variable is able to change the direction or alter the intensity of the relationship (Berkowitz et al., 2015; Frazier et al., 2004). This scenario could, however, not be proven with the current analysis and one possible explanation could be the measure of either school climate or SES used. Other researchers have also tried to test the moderating effect of school climate, but the results have been varied. Research exists that is line with the current findings (Hopson & Lee, 2011; Ruiz, 2016), as well as research that contradicts the findings and proves that school

climate does, in fact, moderate the relationship between SES and achievement (Berkowitz et al., 2015; Rutter, 2006).

The third scenario tested whether school climate was able to mediate the relationship between SES and achievement. Four of the eight school climate factors were found to mediate the relationship between SES and achievement; these are bullying, school emphasis on academic success, the challenges that teachers face and safety in schools. In the case of these four school climate factors, the results show that SES is associated with school climate which, in turn, is associated with learner achievement. This is in line with previously conducted research (Chen & Weikart, 2008; Liu et al., 2015).

Results from the mediation model show that high SES is significantly associated with no occurrences of bullying in schools and, in turn, the result is high learner achievement which is a finding that is supported by past research (Bowes et al., 2009; Lemstra, Nielsen, Rogers, Thompson, & Moraros, 2012). Bullying is not a natural phenomenon but, instead, a result of the social context that learners find themselves in (Tippett & Wolke, 2014). A study conducted by Due and his colleagues in Europe and North America found that schools with the widest fiscal disparity had the highest rates of bullying (Due et al., 2009). This means that focus needs to be directed at the social context of schools. Research also exists that contradicts this SES-Bullying relationship and that finds no association (Ma, 2001; Shetgiri, Lin, & Flores, 2012).

The results also show that high SES is associated with high emphasis being placed of academic success, as well as safety within schools. These are then associated with high academic achievement, which is in agreement with past research (Gustafsson et al., 2016; Kutsyuruba, Klinger, & Hussain, 2015; Nilsen & Gustafsson, 2014). Examination of the concept of socio-economic status being associated with academic success has provided different results from various researchers, some stating that the association was much stronger in low rather than high SES schools (Lee & Smith, 1999). Other researchers state that high-SES schools would have a healthy school climate and would thus place a very high

emphasis on academic success (Nilsen & Gustafsson, 2014) and this is in agreement with the current finding.

5.7 Funding sources

Data used in the current analysis was drawn from the TIMSS project managed by the Education and Skills Development Research Programme in the Human Sciences Research Council. The data is freely available from the HSRC website and hence no costs were incurred while writing the paper

5.8 Conclusion

The results drawn from the current study have highlighted the importance of understanding school climate. Considering that South Africa is a highly unequal society, and that issues of SES still play such a vital role in academic success, school effectiveness research has to be brought to the fore more effectively. There has been a strong move on the part of the DBE to provide low SES schools with adequate physical and human resources in the hope of reducing the inequality gap and hence improving education quality. An area of school effectiveness research that needs a stronger emphasis in the research realm is that of the processes that occur within schools. School climate is one such process and it is clear from the results that it compensates and mediates the relationship between SES and academic achievement. The results have also shown that addressing issues of bullying in schools, lowering the challenges that teachers face, ensuring that schools are safe places for all learners, and placing high emphasis on academic success will, in turn, reduce the SES-achievement gradient.

Chapter 6

6 Towards a model of an open and healthy school climate in South African secondary schools

6.1 Introduction

Research in the area of school climate, an element of the school effectiveness framework (Rumberger & Palardy, 2004), has flourished since the first empirical study conducted by Croft and Halpin (Croft & Halpin, 1963). Educational scholars have been able to identify vital dimensions of school climate and this has enabled the school climate methodology to develop. An area in which there is less agreement is that of an appropriate framework to measure school climate. School climate research, over time, seems to have followed two general trains of thought. The first speaks to the personality of a school and the values in this measure ranged from low, indicating a closed climate, to high, indicating an open school climate (Croft & Halpin, 1963). The second concept refers to the health of a school and was coined by Miles in 1965 (Miles, 1965). A school with a healthy climate is able to thrive in its environment and is able to make adjustments to needed parameters to ensure that it keeps thriving. Since overlaps occurred between the two proposed school climate frameworks, Tschannen-Moran and her fellow researchers developed the School Climate Index (SCI) which combined the open and healthy measures of school climate in an attempt to develop an all-inclusive measure of school climate.

The main aim of the current analysis is to model the SCI and to determine its association with learner mathematics achievement. In addition, the school climate dimensions identified in the Trends in International Mathematics and Science Study (TIMSS) (Mullis et al., 2012) will be modelled together with the SCI to determine if all or some of the dimensions of school climate from either or both frameworks will explain achievement differences within the South African context.

6.2 Literature review

6.2.1 Background to the open and healthy school climate frameworks

Previous research has found a significant link between school climate and learner achievement (Anderson, 1982; Collins & Parson, 2010; Hoy & Hannum, 1998; Koth, Bradshaw, & Leaf, 2008). However, the issue of how to quantitatively and uniformly measure school climate has caused debate over a number years, with similarities occurring between various views but at the same time highlighting subtle differences.

In order to define what school climate is, it is important to track its existence back to the 1960s when research in the area was first done (Croft & Halpin, 1963; Miles, 1965). Croft and Halpin developed the Organizational Climate Description Questionnaire (OCDQ) which was composed of 64 items and was assessed on a scale from open to closed. This framework was focused on the behaviours and interactions of principals and teachers (Hoy & Hannum, 1998) and included factors concentrated around principal supportive behaviour, principal directive behaviour, teacher engaged behaviour, teacher frustrated behaviour and teacher intimate behaviour.

In 1965, Miles conceptualised the healthy school climate framework which consists of an innate hierarchical structure focused on three levels; the managerial level, the technical level and the institutional level. Decisions regarding who teachers are and what is taught are made at the managerial level while the technical level looks at the processes of teaching and learning and, finally, the institutional level places emphasis on the school environment (Miles, 1965). For a school to be healthy, all three of these levels have to operate harmoniously. Leading on from the work done by Miles, authors such as Hoy and Feldman (1987) were able to enhance their knowledge on the organisational health of schools using the Organisational Health Inventory (OHI) framework (Hoy & Feldman, 1987).

Since there were some overlaps between the open and healthy school climates, Tschannen-Moran, Parish, & DiPaola in 2006 consolidated these frameworks into a single multidimensional school climate framework referred to as the School Climate Index (SCI). Using second-order factor analysis, the twelve open-healthy

dimensions were reduced to four robust dimensions which included collegial leadership, teacher professionalism, academic press, and environmental press. The environmental press dimension speaks to interactions between the school and the community surrounding it. Findings from the work done in the 1960s showed this dimension to be negatively associated with achievement, which seemed strange since the opposite is believed to be true (Epstein, 1987; Hoy & Sabo, 1998). One of the conclusions reached was that a possibility existed that a buffering approach could have been assumed – that is, a mechanism used by schools to operate independently of the communities that surround them. In this way it served as a barrier against negative community influences, thus allowing the focus to fall on teaching and learning. An additional problem with the environmental press dimension was that it was not well correlated with any of the other school climate dimensions developed. This meant that the dimension was not working well and it was removed from the revised framework (DiPaola & Tschannen-Moran, 2005; Tschannen-Moran et al., 2006).

Tschannen-Moran and her colleagues believed that using a bridging strategy that includes the community was a better approach (Tschannen-Moran, Parish, & DiPaola, 2006) than a buffering approach. It has been shown that engaging parents and community members in the school and processes surrounding it is positively associated with academic achievement, a finding supported by (Grissom, 2004; Lubienski et al., 2008; Mmotlane, Winnaar, & Wa Kivilu, 2009; Reardon et al., 2011). For this reason they developed a school climate dimension called community engagement to better understand the relationship to other school climate measures and to achievement, as well as to prove that the relationship that exists is positive (Tschannen-Moran et al., 2006). The sections that follow will provide some background on each of the dimensions of the School Climate Index (SCI) and the definitions of each, as outlined by Tschannen-Moran, are provided in Appendix 5.1.

6.2.2 Collegial leadership

This dimension of school climate refers to the relationship between the principal and teachers at a school. Tschannen-Moran, Parish and DiPaola define it as "the behavior of the principal that is supportive and collegial and is not perceived as

overly directive or restrictive" (Tschannen-Moran et al., 2006: 397). One of the purposes of principals within schools is to create a collaborative environment where collegiality will thrive between principals and teachers (Singh, Manser, & Mestry, 2007). The schooling environment that a principal should strive to create is one where collaboration is key and where the inputs from teachers regarding policy development and implementation are taken into consideration (Kochan & Reed, 2005). The principal has the final say in what is taught and by whom it is taught, but teachers need to have an input into this process since they are the ones who need to transfer that information to the learners.

Research regarding the association between collegial leadership and academic achievement is mixed, with some findings showing a significant relationship and others not. One of the assumptions in cases where no association is found is that this dimension does not directly affect teaching and learning but that its effect may be indirect in nature (Tschannen-Moran et al., 2006). Another assumption is that it points to how the dimension has been conceptualised and measured (Marzano, Waters, & McNulty, 2005; Witziers, Bosker, & Krüger, 2003).

A significant relationship between collegial leadership and academic achievement has been found and research has shown that this link is positive in nature (Brand et al., 2003; Dean, 2012), with higher academic achievement being associated positively with collegial leadership. These findings were in line with results from Hauserman and Stick as well as Menon (Hauserman & Stick, 2013; Menon, 2014).

6.2.3 Teacher professionalism

This dimension points to relationships between learners and teachers and between teachers and fellow teachers. The assumption is that schools which display a high level of professionalism have teachers who are dedicated to ensuring that teaching and learning are done optimally and who, more often than not, would go the extra mile to ensure that learner needs are met. Tschannen-Moran, Parish and DiPaola define teacher professionalism as "the behavior that shows that teachers are committed to their work and are willing to work cooperatively with one another" (Tschannen-Moran et al., 2006: 397). In his book, James Stronge lists teacher professionalism as one of the teacher characteristics strongly linked to school

effectiveness and hence academic achievement (Stronge, 2007). In order for learners to effectively absorb what is taught, teachers must have a positive attitude towards their learners (Borko, 2004) and create an atmosphere that is conducive to learning. Teacher professionalism is required when trying to comprehend and apply educational processes within schools and includes drawing from personal characteristics of the teacher, such as their beliefs and attitudes (Drent & Meelissen, 2008), going beyond the number of years they have taught (experience) and their teaching qualification obtained (Caprara et al., 2006).

Qualities that Hoy, Sweetland and Smith associated with teacher professionalism were "respect for colleague competence, autonomous judgment, and mutual cooperation and support of colleagues" (Hoy, Sweetland, & Smith, 2002, pg 42). This means that the professional relationship that teachers have with one another is very important and would assist in being able to collaborate with one another in an attempt to better understand the educational processes and aid in teaching and learning.

6.2.4 Academic press

Academic press refers to the emphasis that schools place on academic success and includes the buy-in of all school staff and learners. Tschannen-Moran, Parish and DiPaola define academic press as the "school wide tone that is serious, orderly, and focused on academics" (Tschannen-Moran et al., 2006, pg 397). They believe that schools that put a substantial amount of effort into academic press strive for excellence and that learners who are strong academically are respected by fellow learners and strive to be like them. It affects all processes within a school that contribute to teaching and learning, such as the curriculum, time on task, accountability (school management, teachers, parents and learners), parental involvement in the academics of their children and school leadership, to name but a few (Bryk et al., 2010; Cannata, Smith, & Taylor Haynes, 2017). Research has also found strong links between learner attitudes (or non-cognitive ability) and academic press (Stankov & Lee, 2014; Swe Khine & Areepattamannil, 2016). Learners who are confident in their academic ability, who find value in what they are taught at school (Juan, Reddy, Namome. C, & Hannan, 2016) and who have a

positive mentality are generally more engaged when being taught concepts within a classroom (Mullis, Martin, Foy, & Hooper, 2016).

Academic press has been found to be strongly associated with academic achievement (Geleta, 2017) which is a finding supported by Tschannen-Moran and her colleagues (Tschannen-Moran et al., 2006). Schools that foster an ethos where a strong emphasis is placed on academic press obtain higher achievement scores, on average, than schools that do not (Cannata et al., 2017).

6.2.5 Community engagement

This school climate dimension is defined by Tschannen-Moran, Parish and DiPaola as "the extent to which the school has fostered a constructive relationship with its community" (Tschannen-Moran et al., 2006, pg 398). Research done earlier, and that included community involvement as a dimension of school climate, found no relationship or a negative relationship existed with academic achievement and, as previously mentioned, a buffering role was then assumed to be the best for schools (Croft & Halpin, 1963; Miles, 1965). This means that schools were required to serve a protective role and thus exclude any kind of community engagement. More recent literature has found very strong links between community engagement and academic achievement (Cavanagh, 2012; Lee, Smith, Perry, & Smylie, 1999; Mo & Singh, 2008; Wood et al., 2017) and the assumption thus made was that the problem was with the methodology used and how the dimension was measured (Tschannen-Moran et al., 2006; Uline et al., 1998). These findings lend themselves to adopting more of a bridging approach between the school and the community surrounding it, where parents and community members support the school in their attempts to providing learners with the best possible opportunities.

6.3 Study purpose and research questions

The purpose of this quantitative study was to determine if a relationship exists between school climate and learner mathematics achievement using data collected from principals, teachers and learners as part of a nationally representative sample of schools and Grade 9 learners in South Africa. The study will investigate two different school climate frameworks, the first is the open and healthy School Climate Index created by Tschannen-Moran and her colleagues in 2006, while the

second will include the school climate framework used by the International Association for the Evaluation of Educational Achievement (IEA) as part of the Trends in International Mathematics and Science Study (TIMSS). The aim of the study was two-fold: Firstly the SCI was modelled to determine which of the school climate dimensions were significantly associated with academic achievement. Secondly, the two frameworks were combined to determine if a school climate model for South African high schools could be developed to explain the variation in achievement between schools. The research questions that were addressed are as follows:

- To what extent are each of the SCI dimensions correlated with one another?
- To what extent are open and healthy school climate dimensions associated with mathematics achievement?
- To what extent are SCI and TIMSS school climate dimensions associated with mathematics achievement?

6.4 Method

6.4.1 Data source and sample

Data for this analysis was extracted from the TIMSS study conducted in the fourth quarter of the academic year in South Africa in 2015. TIMSS is an international trend study which has been conducted every four years since its inception in 1995 by the IEA. A nationally representative sample of schools with Grade 9 classes were selected to form part of the study. Since the study was sample based, a two-stage stratified cluster sampling design was used with schools drawn according to a probability-proportional-to-size (PPS) sampling method at the first stage. The sample was explicitly stratified by province, language of learning and teaching (English, Afrikaans, dual medium) and school type (public and independent). At the second stage, an intact Grade 9 class within the sampled school was randomly selected to form part of the study. The TIMSS South African realised sample consisted of 292 schools/principals, 12 514 learners and 327 mathematics teachers. Details pertaining to the sampling methodology can be obtained from the "Methods and Procedures in TIMSS 2015" report compiled by Martin and colleagues (Martin, Mullis, & Hooper, 2016). Mathematics and science tests were administered to all

learners in the selected class. In addition, contextual instruments were administered to the principal, the teacher of the selected class and the learners to obtain background information since education occurs within a context. The teachers who completed the TIMSS teacher questionnaire were also asked to complete the School Climate Index (SCI) questionnaire which was included as part of the instruments that the teachers were asked to respond to.

Various weights were developed by the IEA to ease analysis since the study is sample based. More details pertaining to the weights can also be found in the "Methods and Procedures in TIMSS 2015" report (Martin et al., 2016). The learner weight – which is the product of the school, class and learner sampling weights – has been used in most TIMSS analysis. However, when doing a multilevel analysis (as is the case in the current study), the learner weight was recalculated to exclude the class weight since this weight was applied at the second level of the analysis.

The analysis included 12 080 learners and 312 teachers from 292 schools. The sample of teachers were smaller than the original sample because not all teachers completed the SCI questionnaires and, since both frameworks were used, the TIMSS school climate data were merged onto the SCI data received. This was also the reason why there were fewer learners included in the analysis compared to the initial sample of 12 514.

6.4.2 Measures

6.4.2.1 Outcome Variable

Learner mathematics scores on the TIMSS assessment was used as the dependent variable in the analysis. As mentioned, TIMSS has been administered every four years since 1995 and, hence, a large mathematics and science item bank has accumulated. With each cycle, three things happen: items are released into the public domain, trend items are kept under lock and key or new items are added to the item bank. Every TIMSS cycle includes between 350 and 450 items, a number too large to expect all learners in the sample to respond to. For this reason, a matrix-sampling approach is used as part of which items are divided into blocks of items and spread across a total of 14 test booklets. To ensure that a trend measure is still

possible, these blocks are replicated over two different booklets and each learner is expected to complete one booklet containing both mathematics and science items.

Since learners were required to answer only a portion of the items, Item Response Theory (IRT) was used to create five plausible values taking the background of the learner into account. These estimates were calculated for each learner to provide total scores that were standardised to an international mean of 500 and a standard deviation of 100 so that, if needed, country comparisons would be possible. For the current analysis, all five plausible values were used.

6.4.2.2 **Independent predictors**

Three sets of independent predictors were selected. The first was learner characteristics that served as controls, the second was the School Climate Index (SCI) dimensions developed by Tschannen-Moran, Parish and DiPaola, and the third was the TIMSS measures of school climate.

Learner-level controls

Six predictors were included in the analysis and served as controls in the model. Gender was included in the model as a dichotomised variable, with girls coded as 1, making up 51% of the sample, and boys coded as 0 (Table 6.1). The average age of learners in the sample was 15.8 years and both age and the square of age were included in the model to test whether the relationship between age and achievement was linear. In the analysis the square of age was included and the age variable was excluded which was an indication an indication that a concave relationship existed between age and achievement. Home socio-economic status (SES) was included in the model as a continuous variable, with high values on the scale indicating high-SES homes and vice versa. SES was standardised to a mean of zero and a standard deviation of one for the South African sample. More details pertaining to how the SES scale was created can be found in Chapter 3 and Chapter 5 of the thesis, or in the unpublished work by Winnaar, Zuze and Blignaut.

Two learner-level TIMSS school climate dimensions (incidence of bullying and learner sense of belonging) were included as a learner-level predictor since

statements pertaining to these dimensions were responded to by the learners. These predictors were aggregated to the school level and included as school-level factors.

Table 6.1: Learner characteristics included in the analysis

Predictor name	Predictor label	Predictor direction	Num. of learners	Mean	Min	Max
GIRL	Gender	Dichotomised (1) Girl, (0) Otherwise	12080	51%	0	1
BSDAGE	Learner age	Lowest to highest	12080	15.78	14	20
AGESQ	Square of age	Lowest to highest age	12080	249.64		397
BULLYING	Incidence of bullying	Low levels to high Levels of bullying	12080	7.48	2.0	14.33
SENSEBEL	Learner sense of belonging	Little to high sense of belonging	12080	7.76	2.10	10.21
ZSES_IRT	Home SES	Low SES to high SES	12080	-0.01	-2.88	2.14

Source: TIMSS 2015 data (author's calculations)

School Climate Index (SCI)

The open and healthy school climate instrument was administered to the teachers who took part in the TIMSS study. It was an additional instrument included as part of the study and consisted of 28 statements that teachers were asked to respond to. All the items included in the instrument were based on a five-point Likert scale with response options: "never" coded as 1, "rarely" coded as 2, "sometimes" coded as 3, "often" coded as 4 and "very often" coded as 5. Negatively versed statements were reverse coded where necessary. The reliability analysis to measure the internal consistency of the instrument was 0.951 using the Cronbach's Alpha, which proved that the instrument was reliable based on a cut-off of above 0.7 (Streiner, Norman, & Cairney, 2015) Since the school climate index was composed of four dimensions, the Cronbach's Alpha for the items included in each dimension was calculated and will be discussed in the next section. The items included in each dimension are provided in Appendix 1.3. Each of the dimensions was created by following three steps developed by Tschannen-Moran, Parish and DiPaola. Details of how these dimensions were calculated were provided in Chapter 3. In the first step, the average score of each of the items was calculated. In the second step the mean score for each of the dimensions was calculated and in the third step the scores on each of the dimensions were standardised to a mean of zero and a standard deviation of one for ease of interpretation and comparison with the TIMSS school climate dimensions.

Table 6.2 provides the variables included from both the open and healthy and TIMSS school climate dimensions.

Collegial leadership (CL)

This dimension included seven statements including statements such as: the principal is friendly, the principal puts teacher suggestions into practice, the principal acknowledges that opinions other than his/her own exist, the principal treats staff as his equal and ensures that lines of communication are always open.

The Cronbach's Alpha for the set of items was 0.90, an indication that the set of items measures the underlying construct very well. The results of the factor analysis indicated that the construct as a single factor explained 63% of the variation.

Teacher professionalism (TP)

This dimension included eight statements that referred to how professional teachers were with their interactions with other teachers, their respect for the competence of their colleagues, how they support fellow teachers as well as learners, how they assist learners, their enthusiasm in getting the job done and whether they are prepared to go the extra mile to ensure that learners succeed.

The dimension was internally consistent, with a Cronbach's Alpha of 0.899 and, as a construct, explained 59% of the variation.

Academic press (AP)

Teachers were asked to respond to six statements that referred to the emphasis that the school places on academic success. They were asked whether the school set high academic standards, whether learners respected other learners who excelled academically, whether academic excellence was acknowledged at the school, whether the learning environment was orderly and serious and whether learners asked for extra work in order to improve their understanding of what was taught.

The items included in the dimension had a Cronbach's Alpha of 0.845 and, after running a factor analysis, the dimension explains 57% of the variance.

Community engagement (CE)

This dimension included seven statements that asked teachers whether they felt that the school made an effort to include the community in the achievement goals of the school, whether the community offered support to the school when needed, whether parents were included in planning committees, whether the community was willing to participate when needed, and whether the school was responsive to concerns expressed by the community.

The dimension was internally consistent with a Cronbach's Alpha of 0.870 and the factor analysis showed that the dimension explained 56.5% of the variance.

TIMSS school climate measures

There were eight school climate dimensions in the TIMSS framework in 2015. The dimensions and their associated Cronbach's Alphas, displayed in brackets, are as follows:

1. The principals' responses to statements that looked at the emphasis placed on academic success (0.89);
2. The teachers' responses to statements that looked at the emphasis placed on academic success (0.91);
3. Teacher job satisfaction (0.91);
4. Challenges that teachers face while at school (0.70);
5. Learner sense of belonging (0.72);
6. Incidence of bullying in schools (0.78);
7. School discipline problems (0.91); and
8. Safe and orderly school environments (0.88).

All the dimensions of the framework were included in the analysis as continuous variables (Table 6.2), with high values on the scale being positive responses – with the exception of the case of the bullying where high scale values were associated with high incidence of bullying in schools. The methodology pertaining to how these dimensions were created can be found in Winnaar, Zuze, Blignaut (unpublished work) or Chapter 3 and 5 of the thesis. All the TIMSS school climate dimensions were standardised to a mean of zero and a standard deviation of one so that comparability with the SCI framework would be possible. Appendix 5.2

provides the dimensions of the TIMSS school climate dimensions with the statements included in each dimension.

Table 6.2: School level characteristics included in the analysis

Source	Predictor name	Predictor label	Predictor direction	Num. of teachers
	MS	Mean mathematics score	Continuous: lowest to highest	317
SCI	CL	Collegial Leadership	Continuous: lowest to highest	317
SCI	TP	Teacher professionalism	Continuous: lowest to highest	317
SCI	AP	Academic Press	Continuous: lowest to highest	317
SCI	CE	Community Involvement	Continuous: lowest to highest	317
TIMSS	Bully	Incidence of bullying at school	Continuous: lowest to highest	317
TIMSS	SB	Sense of Belonging	Continuous: lowest to highest	317
TIMSS	TC	Teacher Challenges	Continuous: lowest to highest	317
TIMSS	TS	Teacher (Safe and orderly)	Continuous: lowest to highest	317
TIMSS	TE	Teacher (Emphasis on academic success)	Continuous: lowest to highest	317
TIMSS	TJS	Teacher Job Satisfaction	Continuous: lowest to highest	317
TIMSS	SE	School (Emphasis on academic success)	Continuous: lowest to highest	317
TIMSS	Disc	Discipline	Continuous: lowest to highest	317

Source: TIMSS 2015 data (author's calculations)

6.4.3 Data analysis plan

6.4.3.1 Descriptive analysis

Correlations were performed to determine if the school dimensions are associated with mathematics achievement, as well as if significant associations exist between the school climate dimensions. The coefficient of determination (R^2) was used to determine the variance explained by each of the school climate dimensions. The descriptive analysis was performed using International Database (IDB) Analyzer developed by the IEA and is appropriate when analysing the TIMSS data because it factors in all plausible values and weighting dynamics when analysis is performed.

6.4.3.2 Hierarchical linear modelling

Multilevel modelling was implemented using a software package called Hierarchical Linear Modelling (HLM v 7.03) designed by Raudenbush and his colleagues (Raudenbush et al., 2013). This is an appropriate analysis package to use since it takes the hierarchical nature of educational data into account. A two-level analysis was performed with learner-level factors included at the first level and the

school climate dimensions included at the second level. Variable centering in HLM is extremely important, especially at level-1. Centering involves subtracting the mean from the predictors and can either be uncentered, grand mean centered or group centered. Uncentered is generally used when dichotomous variables are included which, in the current analysis, would be gender. Grand mean centering subtracts the overall mean of the predictor, whereas with group mean centering, the group mean, which is the school in this case, is subtracted from the learner score on that predictor. The remaining level-1 predictors were grand mean centered.

An HLM analysis generally includes three steps; the first is the unconditional model which includes mathematics achievement as the dependent variable and no predictors are included in the model. The purpose of the step is twofold; firstly it provides information pertaining to the variance explained between and within schools and secondly if the variance between schools, also referred to as the Intraclass Correlation Coefficient (ICC), is greater than 10% then the use of multilevel modelling is justified (O'Dwyer & Parker, 2014). Total variance explained by the HLM model is the sum of the between-school variance (τ_{00}) and the within-school variance (σ^2) and the ICC is calculated as a proportion of the total variance ($\tau_{00} + \sigma^2$).

The learner factors (see Table 6.1) are added in the second step to the first level of the model and only significant factors are retained and interpreted.

The level-1 equation is as follows:

$$Y = \beta_0 + \beta_1*(GIRL) + \beta_2*(BSDAGE) + \beta_3*(AGESQ) + \beta_4*(BULLYING) + \beta_5*(SENSEBEL) + \beta_6*(ZSES\_IRT) + r_{ij}$$

where:

β_p $(p=0,1, \ldots 6)$ are level-1 coefficients and

$r_{ij} \sim N(0, \sigma^2)$ normally distributed with mean zero and variance σ^2.

The school climate dimensions were added at the third stage and two models will be tested and interpreted in the results section of the study. The first level-2 model will include only the SCI dimensions (see Table 6.2) and only significant results will be discussed.

First level-2 model

$\beta_0 = \gamma_{00} + \gamma_{01}*(CL) + \gamma_{02}*(TP) + \gamma_{03}*(AC) + \gamma_{04}*(CE) + \mu_0$

Where:

β_0 : Regression intercept

γ_{00} : average mathematics score across all schools

γ_{01} to γ_{04} : Fixed effect at level-2

The second level-2 model included all dimensions from both the open and healthy and the TIMSS school climate frameworks. The final model will include only the significant factors. The initial second level-2 model will be as follows:

Second level-2 model

$\beta_0 = \gamma_{00} + \gamma_{01}*(CL) + \gamma_{02}*(TP) + \gamma_{03}*(AP) + \gamma_{04}*(CE)$

$+ \gamma_{05}*(BULLY) + \gamma_{06}*(SB) + \gamma_{07}*(TC) + \gamma_{08}*(TS)$

$+ \gamma_{09}*(TE) + \gamma_{010}*(TJS) + \gamma_{011}*(SE) + \gamma_{012}*(DISC) + \mu_0$

Where:

β_0 : Regression intercept

γ_{00} : average mathematics score across all schools

γ_{01} to γ_{012} : Fixed effect at level-2

The analysis will conclude by explaining the amount of variance that each of the school climate frameworks explained, as well as the variance explained by the final model which would be a mixture of the two frameworks. The variance explained by the final model is the difference between level-1 and level-2 between-school variance divided by the level-1 variance (Raudenbush et al., 2004). The formula used to calculate the variance explained by each framework is as follows:

$$\frac{\hat{\tau}_{qq}(Level-1) - \hat{\tau}_{qq}(final\ Level-2)}{\hat{\tau}_{qq}(Level-1)}$$

Where:

$\hat{\tau}_{qq}(Level-1)$ = Estimated variance between schools at level-1

$\hat{\tau}_{qq}(final\ Level-2)$ = Estimated variance between schools at level-2

6.5 Presentation of the results

The results were presented in response to each of the research questions outlined earlier in the paper.

6.5.1 Descriptive analysis

The interpretation of the descriptive statistics in the form of correlations and variance explained was in response to the first research question.

6.5.1.1 To what extent are each of the SCI dimensions correlated with one another?

Table 6.2 shows that all dimensions except learner sense of belonging were significantly associated with mathematics achievement, with correlations (r) ranging from 0.20 (the weakest correlation being with Collegial Leadership) to 0.52 (the strongest correlation with principals' perceptions of the emphasis placed on academic success). Looking at the TIMSS school climate framework, school emphasis on academic success and bullying explained the most variation (r^2) in achievement with 27% and 24% respectively. In the case of the SCI, it is academic press (AP) and community engagement (CE), with 13% and 10% respectively.

All the dimensions of the SCI framework were highly and strongly correlated with each other which, to an extent, is expected as seen from the findings from the work done by Tschannen-Moran and her colleagues (Tschannen-Moran et al., 2006). However, some interesting correlations have been found across the two school climate frameworks and will be mentioned now.

Safe and orderly schools, which was part of the TIMSS framework, is significantly correlated with the four SCI dimensions: Academic press (r =0.60, r^2 = 0.36, p < .01), Community engagement (r =0.50, r^2 = 0.25, p < .01), Teacher professionalism (r =0.44, r^2 = 0.19, p < .01), and Collegial leadership (r =0.40, r^2 = 0.16, p < .01).

The emphasis that teachers placed on academic success from the TIMSS framework was significantly associated with the four SCI dimensions: Academic press (r =0.74, r^2 = 0.55, p < .01), Teacher professionalism (r =0.61, r^2 = 0.37, p < .01), Community involvement (r =0.57, r^2 = 0.32, p < .01), and Collegial leadership (r =0.46, r^2 = 0.21, p < .01).

Within the TIMSS framework, the teachers report on safety and orderliness of schools was significantly correlated with the emphasis placed on academic success (r =0.62, r^2 = 0.38, p < .01), Teacher job satisfaction (r =0.48, r^2 = 0.23, p < .01), the principals report on the emphasis that the school places on academic success (r =0.43, r^2 = 0.18, p < .01), and school discipline (r =0.40, r^2 = 0.16, p < .01).

The emphasis a school placed on academic success in the TIMSS framework (teachers report) was significantly correlated with the principal's report on the same issue, as well as with Teacher job satisfaction (r =0.47, r^2 = 0.22, p < .01).

Table 6.3: Correlations between the two frameworks and achievement

	MS	CL	TP	AP	CE	Bully	SB	TC	TS	TE	TJS	SE	Disc
MS	1												
CL	0.20**	1											
TP	0.26**	0.64**	1										
AP	0.36**	0.61**	0.71**	1									
CE	0.32**	0.60**	0.59**	0.70**	1								
Bully	-0.49**	-0.04	-0.06	-0.11	-0.10	1							
SB	-0.08	0.04	0.04	0.17**	0.12*	-0.15**	1						
TC	-0.35**	-0.15**	-0.15**	-0.15**	-0.10	0.21**	0.03	1					
TS	0.40**	0.40**	0.44**	0.60**	0.50**	-0.17**	0.14*	-0.19**	1				
TE	0.35**	0.46**	0.61**	0.74**	0.57**	-0.13*	0.15**	-0.15**	0.62**	1			
TJS	0.16**	0.40**	0.47**	0.48**	0.38**	-0.03	0.09	-0.10	0.48**	0.47**	1		
SE	0.52**	0.18**	0.25**	0.42**	0.30**	-0.13*	0.13*	-0.25**	0.43**	0.47**	0.25**	1	
Disc	0.39**	0.15**	0.21**	0.31**	0.25**	-0.17**	0.07	-0.21**	0.40**	0.37**	0.24**	0.56**	1

Note: MS= Mathematics score, CL= Collegial leadership, TP= Teacher professionalism, AP= Academic press, CE= Community Engagement, Bully= Incidence of bullying in schools, SB= Sense of belonging, TC= Teacher challenges, TS= Teacher (safe and orderly), TE= Teacher (emphasis on academic success), TJS= Teacher job satisfaction, SE= School (emphasis on academic success), Disc= Discipline

** p-value < 0.01, * p-value <0.05

6.5.2 HLM results

The results for this section will be explained as per the steps outlined earlier, but also in such a manner as to as to respond to the research questions stated earlier.

6.5.2.1 Do significant variations in achievement exist between schools to an extent that warrants multilevel analysis?

Running an unconditional model was the first step of the multilevel analysis and the results provided were also in response to the first research question.

Table 6.4 shows that the weighted least squares estimate for mathematics achievement is 383.60. The null hypothesis of equal mean scores between schools was rejected (χ^2 (311) = 17273.64; p <0.001) in favour of the alternate hypothesis, meaning that schools differ in their average mathematics achievement.

The results showed that the ICC was 0.62 (Table 6.4) and, the closer to one the ICC is, the higher the variation and the more unequal schools are with regard to their achievement. It was clear from these results that, firstly, schools in South Africa remain highly unequal and, secondly, that using multilevel modelling is appropriate.

Table 6.4: HLM Unconditional Model Results – Variance decomposition

Average mathematics score	383.6
χ^2	17273.64***
p-value	< 0.001
Total variance within schools ($\hat{\sigma}^2$)	3236.44
Total variance between schools ($\hat{\tau}^2$)	5280.66
ICC	0.62 = 62%
Reliability (λ)	0.98

Source: TIMSS 2015 data (author's calculations)
Ns – p > 0.10; * p< 0.05; ** p< 0.01; *** p< 0.001;

6.5.2.2 To what extent are the learner-level characteristics associated with mathematics achievement?

The average mathematics achievement once all level-1 predictors were controlled for was 387.59 (Table 6.5), with gender-girls being the strongest predictor associated with achievement. It was negatively associated with achievement in that girls obtained scores of, on average, 10 points lower than boys in mathematics when other predictors are controlled for. Home SES was significantly associated with

mathematics achievement, with one standard deviation increase in home SES being associated with an increase of 3.72 points on average in achievement. Learners who felt that they belonged to the school that they attended scored, on average, 2.29 points higher than learners who had no sense of belonging to the school they attended. Learners who experienced higher incidence of bullying obtained lower scores than learners who were never bullied.

It must be noted that, since the study is cross-sectional, causal inferences could not be made and hence causal direction could not be determined.

Table 6.5: Association between learner characteristics and achievement

	Level-1
Fixed Effects	
Intercept	387.59***
GIRL	-10.33***
AGESQ – Age	-0.49***
ZSES_IRT - Home SES	3.72***
SENSEBEL - Sense of belonging	2.59***
BULLYING – Bullying	-0.95**
Random Effects	χ^2
Intercept	15405.93***

Source: TIMSS 2015 data (author's calculations)
Ns - p > 0.10; * p< 0.05; ** p< 0.01; *** p< 0.001;

6.5.2.3 To what extent are open and healthy school climate dimensions associated with mathematics achievement?

Table 6.5 (model 1) showed that, of the four SCI dimensions, two were significantly and positively associated with mathematics achievement. This meant that learners who attended schools that placed a higher value on academic press (β=16.04, p-value < 0.05), and who engaged with the community surrounding the school (β=13.62, p-value < 0.05), obtained higher scores, on average, than learners who attended schools that did not.

Model 1 explained 14% of the variance in mathematics achievement after controlling for learner characteristics.

6.5.2.4 To what extent are SCI and TIMSS school climate dimensions associated with mathematics achievement?

From the SCI framework, academic press and community involvement were the only dimensions significantly associated with academic achievement. The two dimensions that the SCI and TIMSS framework have in common was the one focused on academic success. When these dimensions were added to the model, the TIMSS dimension showed the largest achievement difference in that learners who attended school where emphasis was placed on academic success scored, on average, 21 points more, with a one standard deviation increase on the dimension, than learners who attended schools where the opposite was true.

School engagement from the SCI framework came through consistently and was positively associated with mathematics achievement. The results showed that a standard deviation increase on the community engagement construct was associated with a 10.51-point improvement in mathematics scores on average.

Incidence of bullying in schools had a significant but negative association with mathematics achievement in that learners who were often bullied scored, on average, 28.35 points lower than learners who were never bullied.

The challenges that teachers face was significantly but negatively associated with academic achievement. Learners who were taught by teachers who were faced with many school-related challenges obtained scores of, on average, 12.72 points lower than learners who were taught by teachers who said they experienced very few or no challenges at school.

When the two school climate frameworks were combined, and the insignificant factors were omitted from the model, the final model (Table 6.6 – model 2) explained 56% of the variance in mathematics achievement when factors at the learner level were controlled for.

Table 6.6: Level- 2 Models of SCI and TIMSS frameworks with achievement

	Model 1: SCI	**Model 2: SCI & TIMSS**
Intercept	385.76***	385.56***
CL= Collegial leadership	*Ns*	*Ns*
TP= Teacher professionalism	*Ns*	*Ns*
AP= Academic press	16.04**	*Ns*
CE= Community involvement	13.63**	10.51**
Bullying = Incidence of bullying at school		-28.35***
SB= Sense of belonging		-18.15***
TC= Teacher challenges		-12.72***
TS= Teacher (safe and orderly)		*Ns*
TE= Teacher (emphasis on academic success)		*Ns*
TJS= Teacher job satisfaction		*Ns*
SE= School (emphasis on academic success)		21.10***
Disc= Discipline		*Ns*
Random effects		
Mean achievement ($\hat{\tau}^2$)	3605.12***	1843.13***
r_{ij} ($\hat{\sigma}^2$)	2874.82	2874.40
Variance explained	0.14 = 14%	0.56 = 56%

Source: TIMSS 2015 data (author's calculations)
Ns - p > 0.10; * p< 0.05; ** p< 0.01; *** p< 0.001;

6.6 Discussion

The aim of this study was twofold. Firstly, it set out to test the relationship between the open and healthy school climate framework and achievement and, secondly, to combine the SCI and TIMSS frameworks to determine if school climate dimensions from each of the frameworks could best explain the academic achievement and climate relationship within the South African context. The results show significant associations between two of the four SCI dimensions (academic press and community engagement) and, in addition, that the SCI dimensions are significantly correlated both with one another and also with some of the TIMSS school climate dimensions. It should be noted that correlations are bidirectional and that they show strengths of relationships; by no means is causality assumed. The safe and orderly and the emphasis placed on academic success TIMSS dimensions were positively and significantly correlated with the four SCI dimensions (academic press, community engagement, teacher professionalism and collegial leadership). This finding is in line with qualitative research done by Berg and colleagues who found that community engagement is an aspect of schooling which encourages a climate

that is safe and, at the same time, links learners to a broader knowledge community (Berg et al., 2006).

A surprising finding was that bullying was not correlated with any of the other school climate dimensions, regardless of the framework used. One would have thought that it would have been strongly correlated with the safe and orderly schools dimension, which could mean that bullying represents a unique school climate dimension in the South African context. Findings from a study conducted in New England, published by Biernbaum and Lotyczewski in 2015 contradict the finding of the current thesis (Biernbaum & Lotyczewski, 2015). These authors found that the dimensions of school climate correlated with bullying are learners' perceptions of relationships between themselves, their peers and teachers; feeling safe while at school; a disciplined environment; and learner engagement in academic activities. The results show that the association between bullying and academic achievement vary largely from one school to another which could mean that levels of bullying are driven largely by factors beyond the school, and beyond the ambit of influence of the principal.

When the combined SCI and TIMSS dimensions were modelled, four of the dimensions were significantly associated with mathematics achievement (community engagement (SCI), bullying (TIMSS), challenges faced by teachers (TIMSS), emphasis placed on academic success (TIMSS)).

Earlier findings suggested that no relationship existed between community engagement and academic achievement and, if such a relationship did exist, that it would a negative one (Croft & Halpin, 1963; Daft, 1995; Miles, 1965; Pennings, 1992). These authors believed that a buffering approach to schooling was required, one in which the school operates independently and without input from the community surrounding it. These findings have been heavily criticised by educational researchers who have stated that not having involvement from communities would have a negative effect on academic achievement (Hoy & Sabo, 1998; Hoy, Tarter, & Kottkamp, 1991). These authors make a case for taking a bridging approach instead, in which the school involves the community in decision making and the direct effect of which is improved academic achievement. This is

supported by the results of the current study. It would thus seem that the problem was not so much about whether a buffering or bridging approach should be taken, but perhaps more about how community engagement is measured (Tschannen-Moran et al., 2006) quantitatively.

An area of school climate that seems to remain very strongly associated with achievement is the incidence of bullying in schools. TIMSS focused analysis, looking at school climate changes since 2003 in public schools in South Africa (Winnaar, Blignaut, Zuze unpublished work), has consistently shown that bullying is negatively associated with academic achievement. This finding is in line with the current findings showing that learners who experience high incidence of bullying obtain scores of, on average, 28 points lower than learners who say they are never bullied at school. The finding of the current study relating bullying in schools to academic achievement is in line with the findings of various authors in the field: (Juvonen, 2007; Lemstra et al., 2012; Lillis & York, 2011; Reddy et al., 2016; Strøm et al., 2013; Wolke, Woods, Stanford, & Schulz, 2001).

The TIMSS dimensions are focused on the challenges that teachers face in schools and look at issues such as large class sizes; too many teaching hours and too little time for lesson preparation; not enough one-on-one time with learners; and too many administrative tasks (Martin et al., 2016). The results showed a negative relationship to exist between the challenges teachers face and academic achievement, with learners obtaining lower scores if taught by teachers who state they have many such challenges when compared to learners taught by teachers who are not faced with these challenges. Authors such as Taylor in 2011 state, and results from the National Education Evaluation and Development Unit (NEEDU) in 2013 show, that time was the resource most poorly used resource by (NEEDU, 2013; Taylor, 2011) which contradicts the time related variables included in the *challenges facing teachers* dimension.

Emphasis placed on academic success (TIMSS) and the *academic press* (SCI) dimensions are positively associated with academic achievement, with the results showing a 21-point difference in learner scores between schools that place an emphasis on academic success and those that do not. This finding is supported by a

number of educational authors: (Astor, Benbenishty, & Estrada, 2009; Cannata et al., 2017; Hoy, Tarter, & Hoy, 2006; Nilsen & Gustafsson, 2014). This dimension focused on factors that would support learning, such as teacher understanding and successful implementation of curricular goals; parental involvement in the education of their children; collaboration between staff at the school; as well as the attitudes of the learners toward their own academic success (Martin et al., 2016).

6.7 Conclusion

The quality of education that learners receive is foremost on the agenda of education departments across the world and is an area in which South Africa struggles, with research showing large variations in academic achievement between schools. This is a point that has been proven in the current analysis as well. Reducing this variation, and thus ensuring homogeneity across all schools in the country, is at the top of the research agenda. Enabling a healthy school climate is one important factor that has been shown to reduce the variation between schools.

Considering that a uniform definition and measure of school climate continues to be investigated by researchers, the aim in this analysis was to focus on two different measures of school climate so as to model the climate that best explains academic achievement in high schools in South Africa. The combined school climate model explained 54 percent of the variation in achievement, which once again highlights the importance of school climate in reducing the inequality between high schools in South Africa.

Effective teaching and learning takes place in schools where the incidence of bullying is not as prevalent, where teachers are faced with fewer challenges that hamper their ability to teach and where the importance of academic success is both acknowledged and emphasised.

A unique contribution made by the study is its highlighting of the importance of community involvement in the education and well-being of all learners. School Governing Bodies (SGB), constitutional bodies composed of educators, parents, non-academic staff and community members, exist in most South African public

schools. The main function of the SGBs is to enrich teaching and learning in schools by ensuring the well-being of all members of a school. Legislation that clearly outlines the functions of SGBs is in place. Unfortunately, however, not all SGB's are equipped with the skills required to carry out their roles effectively. In addition, Union involvement in the selection of teachers impedes the ability of SGBs to successfully fulfil their role in some public schools. The problem in South Africa is that we have well documented policies, however what is lacking is adequate implementation plans for these policies and mechanisms to monitor and evaluate impact.

Chapter 7

7 Concluding remarks and recommendations

7.1 Introduction

The previous chapters have investigated, firstly, how the school climate–achievement relationship has changed over time and, secondly, the importance of the relationship between SES and achievement. This has been achieved by exploring the possibility that school climate could intervene in the relationship between SES and achievement. Finally, by combining two school climate methodologies the result was a joint model of school climate that explains the South African situation.

In addition to the detailed research questions provided in each of the analytical chapters or articles, three broad research questions were stated in Chapter 1. Also, since each of the articles included a detailed discussion of the findings and a conclusion, the main purpose of this chapter is to speak to the link between school climate and inequalities in the South African education system; provide concluding remarks to each of the broad research questions posed in Chapter 1; mention some recommendations; and to point out the limitations of the current study, as well as possible future research that could be conducted in this field. In addition, the chapter will highlight the unique contributions made by the thesis.

7.2 Changes in education quality

Ensuring that all learners have access to a quality education is a goal that all Government departments around the world strive towards. This state of affairs has arisen as a result of a global commitment made, for the first time, in 1990 at the Jomtien World Conference on Education (UNICEF, 1990). This commitment was amended to "achieving education for every citizen in every society" (UNESCO, 2000: 3) and reaffirmed by at least 164 countries around the world at the World Education Forum in April 2000 where the "Dakar Framework for Action, Education for All: Meeting our Collective Commitments" (UNESCO, 2000) was adopted.

Two of the six outcomes outlined in the framework were achieving universal primary education and improving the quality of education.

These outcomes were echoed by the Millennium Development Goals (MDGs) – subsequently replaced by the Sustainable Development Goals (SDGs) at the United Nations Conference in Rio de Janeiro in 2012 and focused on sustainable development. The main aim of the SDGs was to address the economic, political and environmental challenges that countries are confronted with. Goal 4 is focused on education, with its specific aim being to ensure that equitable, quality education is provided to all learners in every country that has adopted the SDGs.

Many industrialised countries were able to strike a balance between the access and quality divide, allowing large numbers of learners to be able to access schools, but not at the cost of quality. The same is true for some developing countries, such as Botswana, that have been able to make slow and steady progress with regard to quality, though it is accepted that the levels of inequality in such countries were not as great as they were in South Africa. These countries paid special attention to developing and implementing appropriate policies that addressed issues of access and quality. They also acknowledged the role that SES plays is far-reaching and, hence, measures were put in place to assist learners from poor SES backgrounds by ensuring that schools would have access to physical resources. There have been large investments in infrastructure for public schools in South Africa – however, these resource inputs have not brought about any considerable reduction in the inequality gaps between schools. In addition, while focusing on resources is important, ensuring that all learners were provided with a good quality education should, perhaps, still have remained at the fore.

Educational quality is an extremely broad concept and encompasses all areas of school life. However, it is often measured in terms of learner or school performance using standardised assessments such as TIMSS, the Progress in International Reading Literacy Study (PIRLS) and those administered by the Southern Africa Consortium for Monitoring Educational Quality (SACMEQ). Since these studies are trend based and designed to measure and monitor changes in academic achievement, countries have been able to monitor their progress, which is used as a

proxy of quality, and improvements in scores are interpreted as improvements in the quality of the education learners are provided with. In South Africa, these studies have shown improvements in achievement scores – thus indicating improved quality – but, unfortunately, this progress has been slow.

By using multilevel analysis techniques, it has been possible to calculate the intraclass correlation coefficient (ICC) which explains variations in achievement between schools and is a good indicator of quality. A high ICC is indicative of high levels of inequality and vice versa. The results from the current analysis comparing ICC's from 2003 to 2015 show that, firstly, the ICC for South Africa is extremely high in relation to other upper middle-income economies such as Botswana, Tunisia and Chile. Secondly, a reduction in the ICC for the country from 67% in 2003 to 57% was observed in public schools in 2015. This is a sign that the education system in the country is moving in the right direction in terms of equity. However, change has been extremely slow. To provide more context, in a country like Finland, an ICC of eight percent means that learners can attend any school in the country and have access to similar quality of education. In this country, the majority of the variance in learner achievement is explained within schools from one learner to another.

Looking at the "input-process-outcome" model of effective schools, significant strides have been made within South Africa in the quest for effective schooling. The focus, however, has always been on the inputs to schooling and what needs to be brought to the fore are the processes within a school that contribute to effective schooling. One such factor is school climate, the focus of this thesis.

7.3 How does school climate relate to academic achievement in public secondary schools in South Africa over time (2002, 2011 and 2015)?

The literature review chapter provided details pertaining to what school climate is, where it originated from and what its importance is in the field of school effectiveness. What the literature also highlighted was the fact that there is neither a universal definition of school climate nor is there a consistent way to measure it. The data used to respond to this research question was extracted from the IEA

measure of school climate within the TIMSS study. It included five dimensions of school climate as measures, these being the educators' and principals' perceptions of the emphasis placed on academic achievement by the school (two separate measures), safe and orderly schools, discipline in schools, and learner incidence of bullying. By 2015, the number of dimensions of school climate within the TIMSS framework had increased but, for the purposes of the trend measure, only five of the eight dimensions consistently appeared across all three the TIMSS cycles that took place between 2003 and 2015.

Learners who were exposed to incidents of bullying at school was one of the dimensions that seemed to have a significant negative relationship with academic achievement across all three the TIMSS cycles. A very slight narrowing of the achievement gap was observed for this dimension – however, across the three cycles, learners who experienced higher incidence of bullying scored an average of 25 score points lower that learners who were not faced with incidents of bullying. This represented a quarter of a standard deviation on the TIMSS scale.

The results showed overall that a positive school climate was associated with high academic achievement, though, in 2003 a climate of discipline had a stronger correlation with achievement. By 2015, however, this seemed to have changed, with school climate explaining achievement differences which could suggest that the climate of schools in South Africa has become more varied than it was in the past. This could be the reason why school climate is the dimension most effectively able to explain variations in achievement.

7.4 To what extent does school climate explain the relationship between SES and academic achievement?

In a country like South Africa, rated as one of the most unequal countries in the world in relation to income with a GINI coefficient of 0.61, the inequality divide persists from generation to generation. The wealthy are able to send their children to better resourced, well-performing schools where they will be provided with a quality education, thus making it more likely that they will reach higher post-schooling goals and reap higher rewards in the labour market. Educational inequalities with regard to socio-economic status or income levels still remain a

massive problem, with learners in poverty-stricken communities attending highly dysfunctional schools that do not offer quality education.

The literature has also provided evidence of the relationship between community poverty and school violence, which in turn is negatively related to academic achievement. This is in addition to the knowledge that high SES is positively related with academic achievement and that the achievement gap between learners from low and high-SES households is widening over time. The main aim of this chapter was to understand the role, if any, that school climate plays in either compensating, moderating or mediating the relationship between SES and academic achievement.

The results from the analysis performed in responding to this research question confirm that a significant positive relationship does indeed exist between SES and academic achievement. The results showed that SES explained 51% of the variation in academic achievement. When the school climate dimensions were added to the model, an additional 14% of the variation in achievement was explained, showing that school climate had a compensatory effect on academic achievement. This means that an encouraging school climate contributes positively to academic achievement over and above the SES influence.

School climate as a moderating effect between SES and academic achievement could not be proven in the current analysis. A moderator variable, in this case school climate, is said to change the direction or alter the relationship between a predictor, SES, and the outcome variable. The research on school climate as the moderating effect is varied, with some researchers having proved it to be true and with other researchers finding that school climate did not moderate the relationship between SES and academic achievement. These varied outcomes could be linked to how both SES and school climate have been measured. Since the literature shows that there is no uniform measure for school climate even though overlaps in the various measures exist. The same is true for SES, where it was measured using resources in the home and parental education, amongst other variables, in the current analysis.

In terms of the mediating effect, four of the eight school climate dimensions were found to mediate the relationship between SES and academic achievement. SES

was significantly associated with learner incidence of bullying (whether they were bullied or not), emphasis placed on academic success, the challenges teachers face and safety in schools which, in turn, is significantly associated with academic achievement. In a nutshell, high SES is associated with high emphasis on academic success, no bullying, very safe school environments and teachers who are faced with few or no challenges, all of which, in turn, result in higher academic achievement.

7.5 To what extent are the two school climate frameworks associated with achievement?

To answer this research question, two school climate frameworks were used. The first was the TIMSS measure, which included a total of eight dimensions which were the teachers' and principals' perceptions (counted separately) of the emphasis that the school places on academic success, school safety and school discipline; incidence of bullying in schools; learner sense of belonging, teacher job satisfaction, and the challenges teachers face in schools. The second framework was a combination of the open and healthy school climate, called the School Climate Index (SCI) and developed by Tschannen-Moran and her colleagues, and included four dimensions which were collegial leadership, teacher professionalism, academic press and community engagement.

Two of the school climate dimensions of the TIMSS framework were significantly correlated with all four of the open and healthy framework dimensions. The safety conditions within a school were strongly and significantly correlated with academic press and community engagement. This result emphasises the importance of the community surrounding the school since the school mirrors the community surrounding it. If communities are considered in decision making within a school, this may lead to safer schools and, hence, schools are able to shift focus from issues of safety to academic success. An interesting finding was the lack of correlation between bullying and all the other school climate dimensions which is an indication that bullying within schools in South Africa might represent a unique school climate dimension.

Using multilevel modelling, the relationship between the TIMSS and open and healthy SCI with academic achievement was tested. Five of the 12 dimensions of school climate were found to be significantly associated with academic achievement. Three of these were from the TIMSS framework, one from the open and healthy framework and the last one, even though it is from TIMSS, is a dimension that exists in the open and healthy framework as well. This is the emphasis that a school places on academic success, or academic press in the open and healthy framework. The importance of this dimension within school climate has been proven within each of the three articles in the current thesis. The first article showed the shift of focus from issues of safety and discipline in 2003 to the emphasis placed on academic success in 2015. The second article showed that whether the focus was on compensating or mediating effects, the emphasis placed on academic success remained a positive and significant contributor in explaining the SES-Achievement dynamic. Finally, in the last article where two different measures of school climate were combined, the importance of this dimension is highlighted yet again.

Incidence of bullying that learners are exposed to as well as the many challenges teachers are faced with are still significant and negatively associated academic achievement. Perhaps, then, as the results in the first article suggest, concerted efforts need to be made to highlight the importance of emphasising academic success. Due to the violent nature of crimes occurring in South African schools and communities, it is possible that learners have become desensitized to criminal acts. This can result in a heightened tolerance for violence. It is quite possible that the TIMSS study actually underestimates the extent of bullying that is taking place.

A dimension that was not considered in the TIMSS framework, but that was shown to be positively and significantly associated with achievement, was community engagement. Where earlier links could not be found – and, as a result, schools served as a buffer between the community and the participants within a school – the results from the current study are in support of bridging the gap between the school and the community. The results have thus highlighted the importance of community involvement in the functioning of schools.

The final combined model explained 51% of the variance in learner academic achievement.

7.6 Study limitations

There are limitations associated with the thesis, the first being that the study was based on secondary data and, thus, the variables included in the analysis were limited to what was available in the research instruments. Considering that the study has a cross-sectional design, the second limitation is that it is not possible to make causal inferences. This means that the relationship between school climate and achievement could flow in either direction. It could also be true that well-performing learners are drawn to a school because it has a positive climate. TIMSS tests a single grade and hence the results would provide a picture of a single school phase only (senior phase in this case), while testing the school climate at the various phases in order to determine the effects at different phases would not be possible. The results were based on learner, principal and teacher perceptions of the various dimensions of school climate. Their responses could thus have been socially desirable and not necessarily a true reflection of the situation within schools. The variables that were included when considering the SES indicator for the second article were limited to what was available within the data. Having additional information, such as household income, to consider would have been an advantage when the SES measure was conceptualised. The resources in the home included in the learner instrument perhaps need refinement to more adequately differentiate between low- and high-SES households.

7.7 Unique contributions made by the thesis

The thesis has extended the knowledge in the field of school climate research and its association with academic achievement. The findings were uniquely placed to measure changes in school climate between 2003 and 2015, as well as testing whether the achievement gap decreased over time.

By acknowledging the importance of SES in explaining achievement difference, the thesis has been able to show that school climate can influence the SES-achievement dynamic. More importantly, it has been proven that schools are able

to make a difference and effect change beyond the SES effect. This can be done by focusing on creating open and healthy school climates.

Finally, and regarded as ground-breaking, is the fact that two different school climate frameworks were considered jointly to determine if school climate measures that best describe the South African context could be identified. Between the two frameworks, a total of 12 school climate dimensions were included; eight from TIMSS and four from the open and healthy SCI. Of these, only five dimensions were significantly related to achievement. This could suggest that the TIMSS measure may not be an ideal fit for the South African context.

7.8 Recommendations

Schools need to take a stronger stance against bullying and violence by monitoring the various types of violent acts being committed on their premises and how often these occur, especially given the consistency of the findings relating to bullying over time. This will then allow schools to develop and implement adequate policies for dealing with the destructive behaviour that still exists. Community involvement in the schooling of their children is vital and this was proven in the results of the thesis. Policies should be created and implemented by government to assist communities in addressing issues of violence, since research has shown that schools mirror the communities surrounding them.

There needs to be a stronger focus on the importance of academic achievement within schools. This, however, should not be purely focused on assessment but rather should look at the intangible aspects of schooling that enhance academic success. These would include, but not be limited to, ensuring that teachers are satisfied with their jobs, that learners feel like they belong to the school they attend and that the challenges that teachers face and that hamper productivity are reduced.

The DBE has developed the National School Safety Framework which needs to be implemented in schools. Procedures need also to be put in place to monitor and evaluate the implementation of this framework.

An insight arising from the analysis has been the SES-achievement relationship and the effects that school climate has in compensating and mediating this relationship.

South Africa remains a highly unequal society with regard to income and this is reflected in the quality of education provided to various groups of learners. The results have shown that, by focusing on school climate, schools can make a difference regardless of the SES background of the learner.

Issues of school-based violence and bullying in schools need to be solved proactively, not reactively as has been the case to date. One such proactive plan would be to focus on school climate and creating a measure that will allow education stakeholders at the various levels to monitor progress in schools.

7.9 Future research

The findings provided in the thesis have highlighted the importance of school climate as a process within the school effectiveness framework. The findings have also demonstrated that school climate can either compensate or mediate the relationship between SES and academic achievement. In the case of South Africa, which remains highly unequal, this could mean that, regardless of the home background a learner is from, if the school climate is open and healthy, learners would have a greater chance to succeed academically. It is also clear that there has been a shift in focus with regard to the school climate dimensions, with school emphasis on academic achievement being highly significant in 2015, as opposed to the emphasis on safety and discipline in earlier cycles. This indicates a shift in a positive direction.

Using the current findings as a basis, qualitative research to deepen our understanding of the intangible factors of schooling would be beneficial, especially when the analysis is broadened to include all the phases of schooling. This will deepen our understanding of how school climate functions in the various phases of schooling.

Also of benefit would be working with the National School Climate Centre (NSCC) based at the University of Columbia design a school improvement strategy. The NSCC has undertaken extensive research in the field of school climate and has developed a five-stage improvement process that is informed by data and managed by people (at the school, district and province), and has a strong focus on collective

leadership. Working with the NSCC would allow South Africa to develop a school climate strategy that is relevant locally. Future research, both quantitative and qualitative, to measure the effectiveness of these new efforts w be necessary.

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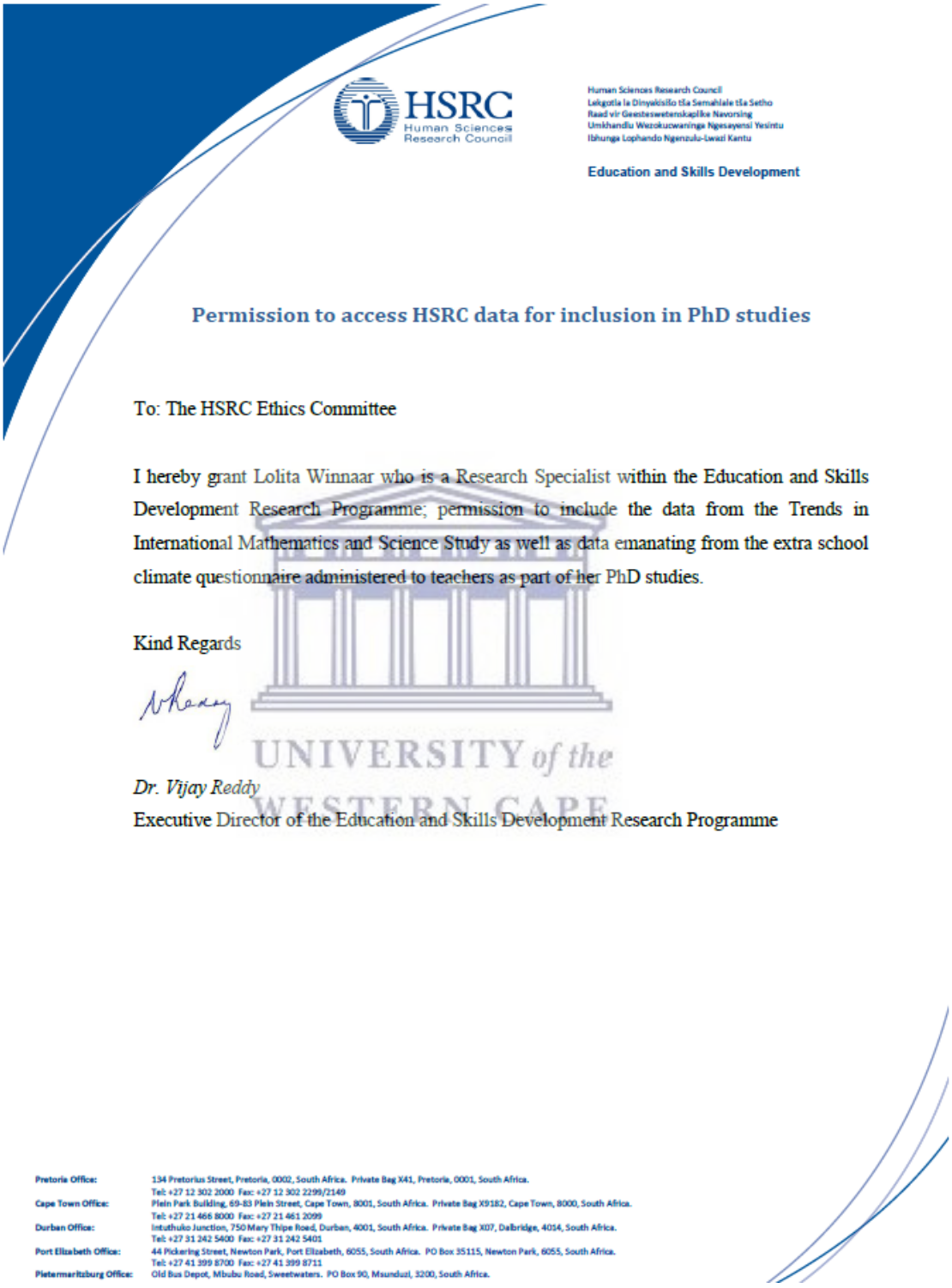
Appendixes

Appendix 1.1: Letter of permission to use the data



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Umkhandlu Wezokuzwaniriga Ngesayensi Yesintu
Ibhunga Lophando Ngenzulu-Lwazi Kantu

Education and Skills Development

Permission to access HSRC data for inclusion in PhD studies

To: The HSRC Ethics Committee

I hereby grant Lolita Winnaar who is a Research Specialist within the Education and Skills Development Research Programme; permission to include the data from the Trends in International Mathematics and Science Study as well as data emanating from the extra school climate questionnaire administered to teachers as part of her PhD studies.

Kind Regards

Dr. Vijay Reddy
Executive Director of the Education and Skills Development Research Programme

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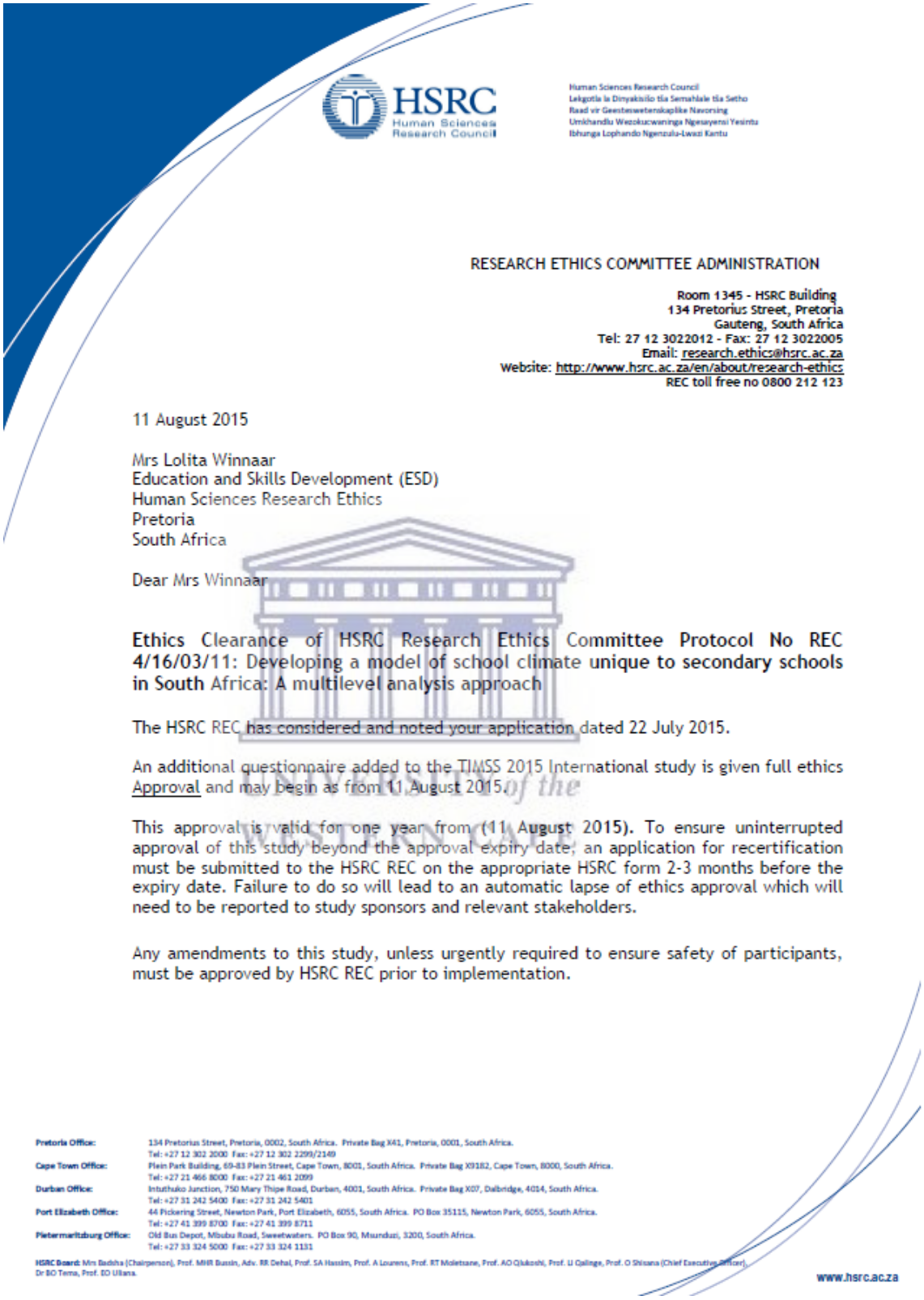
Pietermaritzburg Office: Old Bus Depot, Mbubu Road, Sweetwaters. PO Box 90, Msunduzi, 3200, South Africa.

Appendix 1.2: Ethical clearance to administer the SCI instrument



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RESEARCH ETHICS COMMITTEE ADMINISTRATION

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REC toll free no 0800 212 123

11 August 2015

Mrs Lolita Winnaar
Education and Skills Development (ESD)
Human Sciences Research Ethics
Pretoria
South Africa

Dear Mrs Winnaar

Ethics Clearance of HSRC Research Ethics Committee Protocol No REC 4/16/03/11: Developing a model of school climate unique to secondary schools in South Africa: A multilevel analysis approach

The HSRC REC has considered and noted your application dated 22 July 2015.

An additional questionnaire added to the TIMSS 2015 International study is given full ethics Approval and may begin as from 11 August 2015.

This approval is valid for one year from (11 August 2015). To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to the HSRC REC on the appropriate HSRC form 2-3 months before the expiry date. Failure to do so will lead to an automatic lapse of ethics approval which will need to be reported to study sponsors and relevant stakeholders.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by HSRC REC prior to implementation.

Appendix 1.3: Open and healthy school climate index (SCI)

THE SCHOOL CLIMATE INDEX (SCI)

TEACHER QUESTIONNAIRE

The following are statements about your school. Please indicate the extent to which each occurs, from Never (1) to Very frequently (5).

	Never	Rarely	Some times	Often	Very often
1. Our school makes an effort to inform the community about our goals and achievements.	1	2	3	4	5
2. Our school is able to marshal community support when needed.	1	2	3	4	5
3. The interactions between the teaching staff members are cooperative.	1	2	3	4	5
4. Teachers respect the professional competence of their colleagues.	1	2	3	4	5
5. The school sets high standards for academic performance.	1	2	3	4	5
6. Students respect others who get good grades.	1	2	3	4	5
7. The principal is friendly and approachable.	1	2	3	4	5
8. The principal puts suggestions made by the teaching staff into operation.	1	2	3	4	5
9. Parents and other community members are included on planning committees.	1	2	3	4	5
10. Community members are responsive to requests for participation.	1	2	3	4	5
11. Teachers help and support each other.	1	2	3	4	5
12. Teachers in this school exercise professional judgment.	1	2	3	4	5
13. Teachers are committed to helping students.	1	2	3	4	5
14. Academic achievement is recognized and acknowledged by the school.	1	2	3	4	5
15. Students try hard to improve on previous work.	1	2	3	4	5
16. The principal explores all sides of topics and admits that other opinions exist.	1	2	3	4	5
17. The principal treats all the teaching staff members as his or her equal.	1	2	3	4	5
18. Teachers accomplish their jobs with enthusiasm.	1	2	3	4	5
19. Teachers "go the extra mile" with their students.	1	2	3	4	5
20. Teachers provide strong social support for colleagues.	1	2	3	4	5
21. The learning environment is orderly and serious.	1	2	3	4	5
22. Students seek extra work so they can get good grades.	1	2	3	4	5
23. The principal is willing to make changes.	1	2	3	4	5
24. The principal lets the teaching staff know what is expected of them.	1	2	3	4	5
25. The principal maintains definite standards of performance.	1	2	3	4	5
26. Community members attend meetings to stay informed about our school.	1	2	3	4	5
27. Organized community groups (e.g., PTA, PTO) meet regularly to discuss school issues.	1	2	3	4	5
28. School people are responsive to the needs and concerns expressed by community members.	1	2	3	4	5

The survey was downloaded from http://mxtsch.people.wm.edu/research_tools.php and was developed by Dr. Megan Tschannen-Moran and her colleagues

Appendix 3.1: Item parameter estimates

Item Parameter Estimates					
Response Model	**Item**	**Parameter**	**Estimate**	**Standard Error**	**Pr > |t|**
Graded	**NumBooks**	**Threshold 1**	-0.230	0.012	<.0001
		Threshold 2	0.888	0.014	<.0001
		Slope	**0.387**	0.012	<.0001
	ICT_HME	**Threshold 1**	-1.472	0.019	<.0001
		Threshold 2	-0.053	0.014	<.0001
		Threshold 3	0.807	0.016	<.0001
		Slope	0.789	0.015	<.0001
	ParEduc1	**Threshold 1**	-1.366	0.017	<.0001
		Threshold 2	0.100	0.012	<.0001
		Slope	**0.423**	0.013	<.0001
	Famstruc	**Threshold**	-0.580	0.012	<.0001
		Slope	**0.161**	0.014	<.0001
	Q6b	**Threshold**	0.243	0.012	<.0001
		Slope	**0.443**	0.015	<.0001
TwoP	**Q6a**	**Threshold**	0.593	0.015	<.0001
		Slope	0.754	0.019	<.0001
	Q6c	**Threshold**	-0.298	0.013	<.0001
		Slope	0.463	0.015	<.0001
	Q6d	**Threshold**	-0.514	0.013	<.0001
		Slope	0.491	0.016	<.0001
	Q6e	**Threshold**	-0.122	0.014	<.0001
		Slope	0.744	0.018	<.0001
	Q6f	**Threshold**	-1.003	0.016	<.0001
		Slope	0.593	0.019	<.0001
	Q6g	**Threshold**	0.639	0.016	<.0001
		Slope	0.808	0.020	<.0001
	Q6h	**Threshold**	-0.884	0.016	<.0001
		Slope	0.643	0.019	<.0001
	Q6i	**Threshold**	-2.338	0.054	<.0001
		Slope	1.369	0.048	<.0001
	Q6j	**Threshold**	-0.849	0.017	<.0001
		Slope	0.779	0.021	<.0001
	Q6k	**Threshold**	-2.921	0.090	<.0001
		Slope	1.865	0.075	<.0001
	Q6l	**Threshold**	-1.388	0.024	<.0001
		Slope	0.938	0.027	<.0001
	Q6m	**Threshold**	-0.404	0.016	<.0001
		Slope	0.881	0.021	<.0001
	Q6n	**Threshold**	-0.043	0.015	0.002
		Slope	0.865	0.020	<.0001
	Q6o	**Threshold**	1.080	0.016	<.0001
		Slope	0.550	0.018	<.0001
	Q6p	**Threshold**	-2.117	0.045	<.0001
		Slope	1.265	0.042	<.0001

Appendix 5.1: Open and healthy SCI defined

Source: http://wmpeople.wm.edu/site/page/mxtsch/researchtools (Tschannen-Moran et al., 2006)

Collegial Leadership

Collegial leadership is characterized by behaviour of the principal that is supportive and egalitarian. The principal is considerate, helpful, and genuinely concerned about the welfare of teachers. At the same time, the principal lets faculty know what is expected of them and maintains definite standards of performance. The principal is open to exploring all sides of topics and willing to make changes. He or she accepts questions without appearing to snub teachers, and admits that divergent opinions exist. The principal takes an interest in classroom issues that are important to teachers.

Teacher Professionalism

Teacher professionalism describes teacher behavior characterized by commitment to students and engagement in the teaching task. Teachers respect the professional expertise of colleagues. Professional interactions among teachers are open and cooperative. Teachers are supportive of one another and help one another. Teachers display warmth and friendliness.

Academic Press

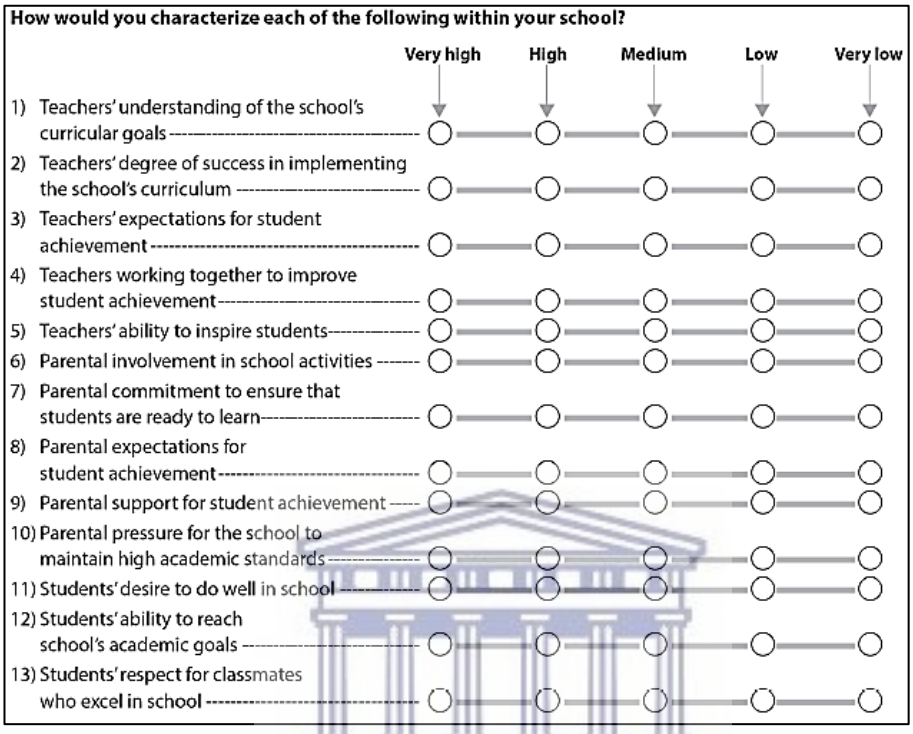
Academic press is the extent to which the school is driven by a quest for excellence. Teachers and administrators set a tone that is serious, orderly, and focused on academics. High but achievable goals are set for students, and students respond positively to the challenge of these goals. They work hard and respect the academic accomplishments of their peers.

Community Engagement

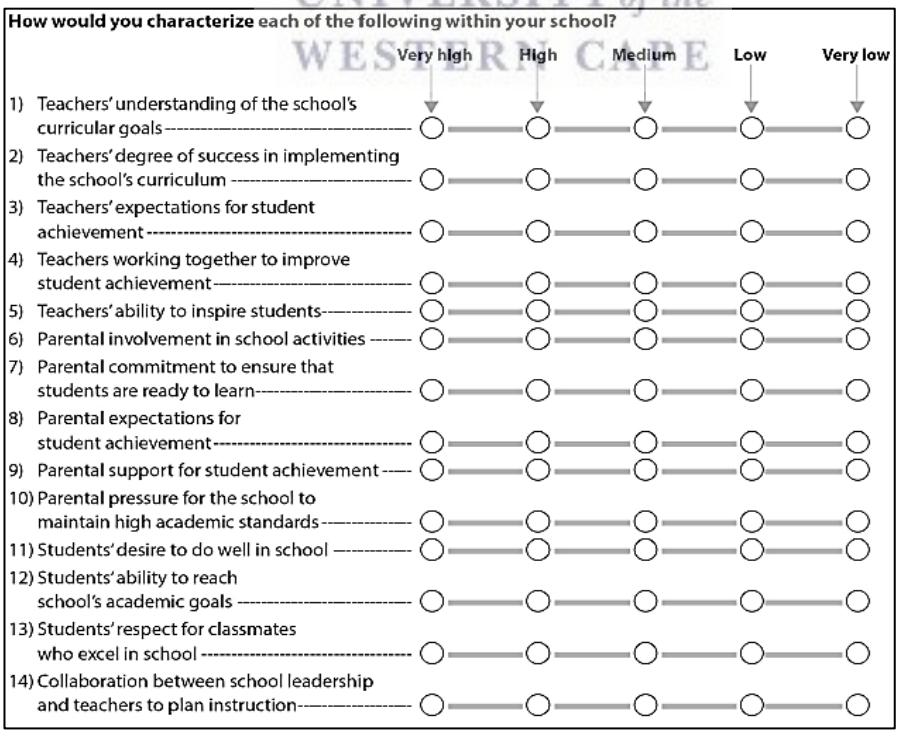
Community engagement is the extent to which the school has fostered a constructive relationship with its community. This measure describes the degree to which the school can count on involvement and support from parents and community members, and the extent to which the school provides the community with information about its accomplishments.

Appendix 5.2: Statements included in each of the TIMSS school climate dimensions (Martin et al., 2015)

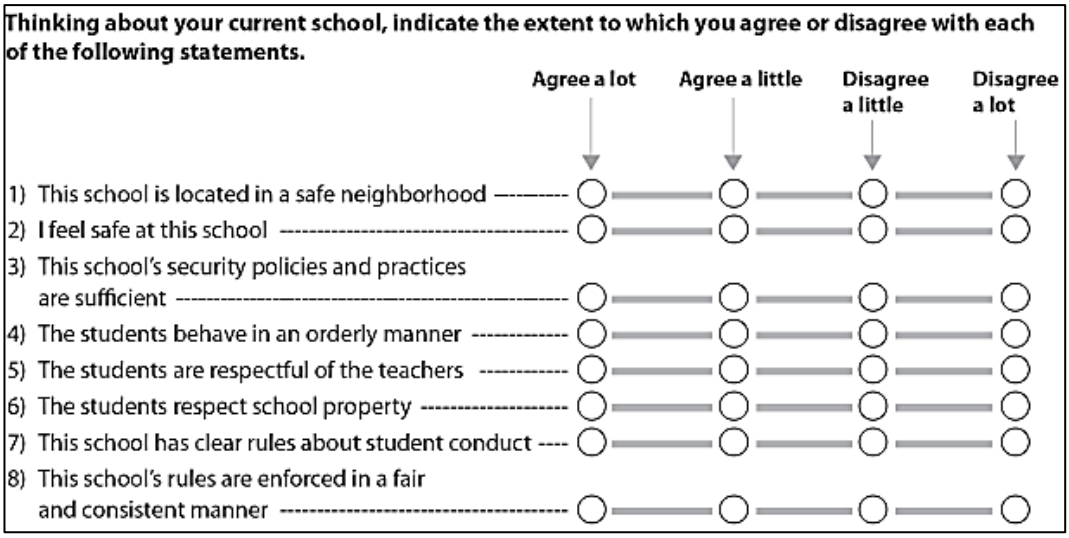
1. **Emphasis placed on academic success (school principal instrument)**:



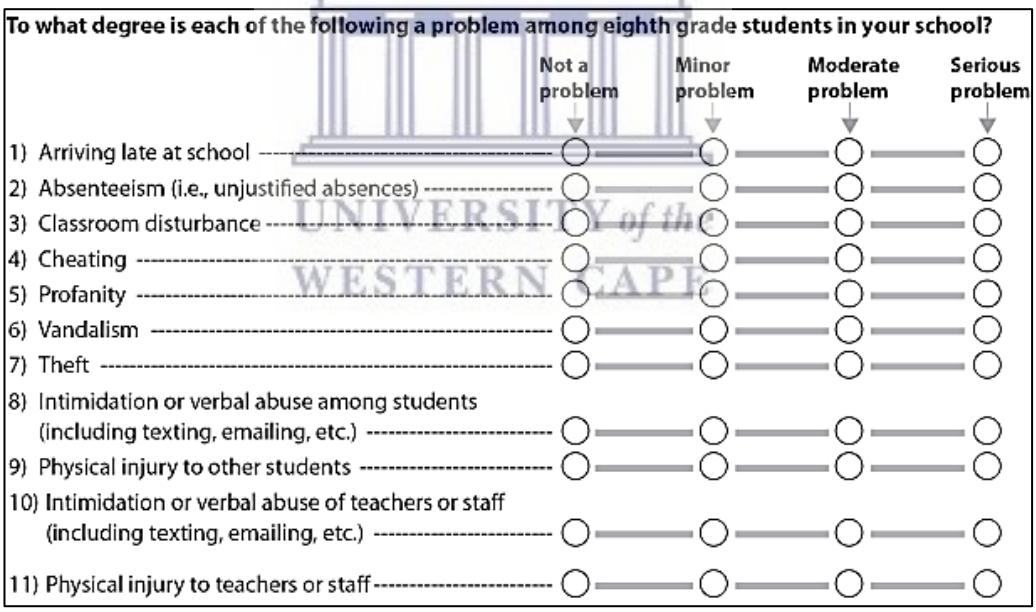
2. **Emphasis placed on academic success (mathematics teacher instrument):**



3. Safe and orderly school:



4. School discipline problems:



5. Teacher job satisfaction:

How often do you feel the following way about being a teacher?

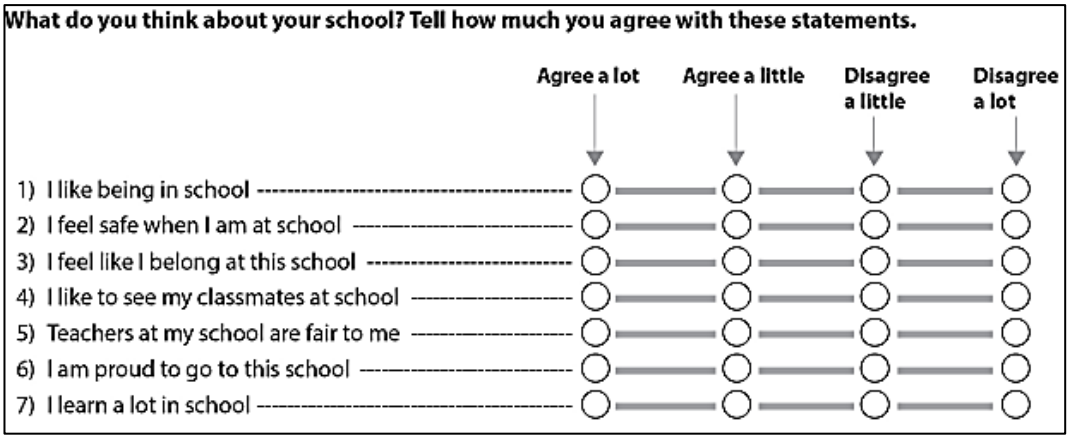
	Very often	Often	Sometimes	Never or almost never
1) I am content with my profession as a teacher	○	○	○	○
2) I am satisfied with being a teacher at this school	○	○	○	○
3) I find my work full of meaning and purpose	○	○	○	○
4) I am enthusiastic about my job	○	○	○	○
5) My work inspires me	○	○	○	○
6) I am proud of the work I do	○	○	○	○
7) I am going to continue teaching for as long as I can	○	○	○	○

6. Challenges facing teachers:

Indicate the extent to which you agree or disagree with each of the following statements.

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
1) There are too many students in the classes	○	○	○	○
2) I have too much material to cover in class	○	○	○	○
3) I have too many teaching hours	○	○	○	○
4) I need more time to prepare for class	○	○	○	○
5) I need more time to assist individual students	○	○	○	○
6) I feel too much pressure from parents	○	○	○	○
7) I have difficulty keeping up with all the changes to the curriculum	○	○	○	○
8) I have too many administrative tasks	○	○	○	○

7. Sense of belonging:



8. Learner bullying: