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CONDITIONS OF SCHOOLING IN SOUTH AFRICA AND THE EFFECT ON MATHEMATICS ACHIEVEMENT

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South Africa participated in TIMSS in 1995 and again in 1998. However, no data on school or teacher level could be analysed to provide the context for the students' poor achievements in mathematics and science in 1995. With the 1998 data now available at both school and teacher level in addition to the student level data, this backdrop to the results can be provided. Questions on school level regarding the leadership of the school, the physical conditions within the schools, the students' behaviour, the schools' expectations of parents as well as information regarding teachers will be investigated in relation to mathematics achievement. More than 80% of the sample comprised schools, which are disadvantaged in terms of human and physical resources. An analysis of the data from the principal's questionnaire will be done to ascertain the effect of the conditions within these disadvantaged schools on the students' performance.

CONDITIONS OF SCHOOLING IN SOUTH AFRICA AND THE EFFECT ON MATHEMATICS ACHIEVEMENT

1. Introduction

At the end of the 20th century, it was estimated that about 140 million people in sub-Saharan Africa could not read or write. Amongst South Africa's multi-cultural society of 39 million people, more than 3 million adults over the age of 16 have never attended school and more than 2.5 million attended only a few years in school and are functionally illiterate. Much of this is directly attributable to the decades of *Apartheid* policies implemented under the nationalist government of South Africa. These separatist policies forced cultural groups apart under the guise of separate development. The education system became divided with children of each race group attending school separated on the basis of these racial groupings. Schools for white children received much more funding than others, had better facilities, were better equipped and had better qualified teachers. Therefore, in addition to the other challenges facing the rest of Africa, South Africa has a set of special circumstances to deal with.

One of the most noticeable changes after the democratic elections in 1994, was the dramatic change in the demography of students at previously white, coloured and Indian schools. Students from the townships (speaking mostly African-languages at home) poured into all of these schools, whilst many Indian and coloured (of mixed-race) children moved into former white government schools. In areas like Johannesburg where the diversity of languages is vast, there are obvious consequences for instruction in the classrooms. One of the key problems is that in the majority of schools the official language of instruction and the mother tongue of the teachers and/or the students are different. The result of this is that students' achievement in mathematics (and other subjects) is negatively affected.

This paper covers only part of a larger research project (Howie, 2000), being conducted by the Human Sciences Research Council (the National Co-ordinating Centre for in the Third International Mathematics and Science Study (TIMSS) in South Africa). The larger project analyses the performance of the South African students in mathematics and science within an international comparative perspective as participant in the Third International Mathematics and Science Study-Repeat (TIMSS-R). TIMSS-R was conducted in 1998/1999 (and TIMSS in 1995 (see Howie, 1996)) under the auspices of the International Association for the Evaluation of Educational Achievement (IEA).

This study builds on the work done by a number of researchers from other countries (Mohandos, 1999 and Afrassa, 1998 amongst others) and most recently upon the study conducted by Bos (2000) on student achievement in mathematics in the Netherlands. Ultimately the project aims to describe and explore the performance of the South African students in mathematics and the relationship between mathematics achievement and students' proficiency in English, as well as other background variables. The factors relating to the students performance in mathematics and English language proficiency will be explored in relation to the background information that was collected from the students, teachers and principals of the schools included in the study.

The aim of the exploration is also to try to ascertain which of the two levels (student-level or class/school-level) has the most influence on students' achievement mathematics in the context of South Africa. Evidence from previous research suggests that whilst student-level factors have more influence on students' achievement in developed countries (Husen, 1967), school-level factors play a greater role with regard to students' achievement in developing countries (Heyneman, 1975 and Keeves, 1994). It is therefore believed that school-level factors are likely to play a more significant role with regard to South African Grade 8 students' achievement in mathematics than student-level factors. However, it is also recognised that due to the disparity in the home backgrounds of the students that the home factors and school factors may play a greater or lesser role depending on the background of different groups of students. Therefore, the variables relating to the home background will be explored to determine how or whether they affect the achievement of different groups of students differently. In addition, the school factors will also be investigated to see how or whether they affect the achievement of different groups of students in divergent ways.

However, this paper is only the first part of this exploration of the TIMSS-R data involving multivariate and multilevel analysis. Here attempts are made to find factors at school-level that helps to explain the variance within the South Africa student's achievement data. Factors relating to the leadership, the physical conditions, the school's expectations of the parents and the school environment are explored here in relation to the performance of South African students in TIMSS-R.

The rest of the paper comprises the following. Section 2 provides an overview of some of the literature dealing with school level factors and their relationship to achievement. Thereafter, a description of the South African education context is given in section 3. Section 4 provides the reader with background information on the TIMSS-R project. The research design is described in section 5 and includes the conceptual framework for the larger research project. Finally section 6 contains the results of the study and some preliminary conclusions about the results to date.

2. School level factors related to achievement

Research at school level has been underway for more than 30 years. During this time, research has assumed a number of mantles namely school effectiveness, school improvement, school reform, school development, and school restructuring amongst others. Through this research a number of factors related to achievement have been uncovered at different levels in the education system, i.e. at school-, class- and student-level. Many authors attribute the start of this type of research to the team under Coleman, 1966 who found that home background predicted by far the greatest variance in achievement outcomes. Using multiple regression analysis, Coleman reported that poverty and class were responsible for predicting achievement more reliably than school factors. School-level factors have traditionally explained a low percentage of variance in many research projects. Reynolds and Cuttance (1992) reviewed a number of studies and found only 8-15% of variance attributable to school factors.

A number of studies also tried to prove the effectiveness of schools. New techniques were developed to do this. Edmond's 5-factor model (1979) was developed through a longitudinal study and Rutter et al (1979) and Mortimore et al (1988) used complex data and multilevel analysis techniques for the first time.

A variety of factors have been found that influence achievement. Specifically, it has been reported, in a review by Greenwald, Hedges and Laine (1996) that a number of studies found class size to have a minor effect on achievement. Fuller and Clarke (1994) identified three factors – *textbooks*, *teacher quality* and *time* as being key factors emerging from school effectiveness research. These are also mentioned by Riddell (1997) and in a review by Creemers (1996). *Leadership, organisation and management* are identified as important factors by school effectiveness researchers, whilst school improvement researchers have concentrated on *decision-making, within-school hierarchy* and *communication.* Recent findings in school effectiveness studies show that school-level factors influence achievement far less than do factors at the class-level. However, as this research is largely based in developed countries, the question is whether this is also the case in less-developed nations.

In the past few years, calls have been made to link school interventions and contextual information with student achievement data. West and Hopkins (1996) stated that a school improvement strategy needs to be based on data about student performance claiming that different achievement profiles require different kinds of intervention.

As mentioned earlier, the situation in developed and developing countries may well be different in relation to outcomes in research on school level and in which factors influence student achievement. One important difference is that resources at schools are important in developing countries. The World Bank (1995) lists libraries, time on task, homework, textbook provision, teacher knowledge, teacher experience, laboratories, teacher salaries and class size as important for effective schooling in developing countries. Other influential factors found are teacher expertise and competence, strong leadership, clear organisation of the school day and the learning programme (time and opportunity) and community and parental involvement in school governance (Muller's, 2000:8). In South Africa, an investigation into well performing schools by Crouch and Mabogoane, (1998) found that only 25% of achievement was explainable by resource availability.

Not only is there a difference between developed and developing countries but there is also a significant difference between the variance in achievement explained at different education levels between and within-countries. A Reynolds (1998:1279) claim that classroom-level has "*maybe two or three times the influence on student achievement than the school level does*".

Scheerens (1998) conducted an extensive review of the literature on school effectiveness the results of which are encapsulated in the table below. A synthesis of the research outcomes revealed support for Reynolds earlier conclusion. A cursory look over Table 2.1 shows that factors at classroom level correlate generally more highly than at school level.

Table 2.1: Review of evidence from qualitative review, international studies and research syntheses

	Qualitative reviews	International analyses	Research syntheses
Resource input variables			
Pupil-teacher ratio		0.03	0.02
Teacher training		0.00	-0.03
Teacher experience			0.04
Teacher salaries			-0.07
Expenditure per pupil			0.20
School organisational factors			
Productive climate culture	+		
Achievement press for basic subjects	+	0.02	0.14
Educational leadership	+	0.04	0.05
Monitoring/evaluation	+	0.00	0.15
Co-operation/consensus	+	-0.02	0.02
Parental involvement	+	0.08	0.13
Staff development			
High expectations	+	0.20	
Orderly climate	+	0.04	-0.11
Instructional conditions			
Opportunity to learn	+	0.15	0.09
Time on task	+	.00/-.01 (n.s)	0.19/0.06
Structured teaching	+	-0.01 (n.s)	0.11 (n.s)
Aspects of structured teaching			
• co-operative learning			.27
• feedback			.48
• reinforcement			.58
Differentiation/adaptive instruction			.22

Scheerens (1998:1110)

In another review of literature at school level Muller (2000:17) concludes that home background is more influential than school *because most of the damage is done before the children go to school.* However, the complexity and peculiarities of schools maybe magnified by highly disadvantaged settings such as those in South Africa and other developing countries. There is a need to explore and disentangle the multiple associations and divergent outcomes derived from the same set of input variables. Multilevel modelling may be seen as an aid to do this, hence the growing tendency by researchers to use this technique. It is clear that although researchers may be approaching data from different perspectives (i.e. school improvement or school effectiveness), there is considerable interest in ascertaining the reasons related to the successful learning of students in schools across the world. Seemingly instructional factors at classroom level are more important than factors at school-level. In the developed world, researchers maintain that home background factors predict achievement of children in those countries. It is with these results in mind that this research was undertaken, to explore and investigate to what extent factors at school level had any influence on the achievement of South African students in mathematics.

3. Education in South Africa

Education in South Africa is compulsory and free for grades 1 to 9, and non-compulsory for grades 10 to 12. Students are only expected to pay fees for grades 10 to 12, but educational user fees are widespread in all the grades. Primary school spans grades 1 to 7, whilst grades 8 to 12 constitutes the secondary school. In 1996, there were 12 million learners enrolled at schools in South Africa, of whom two thirds were in primary school. The majority of South African secondary schools are comprehensive; however, there are a limited number of schools that provide commercial or technical subjects. In 1996 all provinces had teacher/learner ratios below official targets of 40:1 for primary schools, and 35:1 for secondary schools. In general, teachers in government schools are faced with large classes.

South Africa has both government (public) and private (independent) schools within its education system. Only a small proportion of all learners (3%) in South Africa is enrolled at private schools. The average teacher/learner ratio at 25:1 in these schools is more favourable than that in government funded schools; and it can even be as low as 14:1.

A considerable number of schools in South Africa suffer serious shortcomings, ranging from poor access to water, telephones and electricity, to the poor condition of many school buildings. In an HSRC survey of school needs (1996), 12% of schools had no sanitation facilities, 24% had no water within walking distance, and 59% had no telephones. Only 49% of schools had adequate provision of textbooks.

Most teachers have a 3- or 4-year teaching diploma from a teacher training college, although teacher training is also offered at postgraduate level. Due to an excess of teacher training colleges, several of them were closed or amalgamated during 1996. Teacher qualifications in mathematics are of some concern, as most mathematics teachers are not qualified to teach these subjects. Although 85% of mathematics teachers are professionally qualified, only 50% have specialised in mathematics.

The ethos at South African schools has deteriorated over the years, making it sometimes not conducive to academic activity. Teacher rationalisation, the most dominant educational debate over the past three years, has contributed to this decline. This process involved voluntary severance packages and redeployment of teachers to other areas. The insecure environment in which teachers have had to operate (large classes, the threat of unemployment) has resulted in low teacher morale and disillusionment. A worsening problem in South African schools is that of the increasing violence rate. The department of education launched a 'Culture of Teaching and Learning' campaign to eliminate drugs, rape and sexual harassment, vandalism, weapons and all forms of violence, in an attempt to restore a work ethic in schools.

In 1993, of the 157 701 pupils who wrote the mathematics exam, only 80 050 (51%) passed representing 17% of the total number of candidates entering the matriculation exams in that year. By 1998, although the enrolment figure had increased by more than 120 000 pupils, the pass rate had dropped to 42%. As data by racial group is no longer reported, it is not possible to gauge the current status quo in 1999. It appears however, that more African pupils are enrolling in these subjects, but there has been a corresponding drop in the overall pass rate.

4. Background on TIMSS-R

4.1 The Third International Mathematics and Science Study

The Third International Mathematics and Science Study, conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA) is the single largest international comparative study (see Beaton et al, 1996a&b) ever conducted in education. In 1994 and 1995, more than 40 countries, 15 000 schools and 500 000 students participated in over 30 languages. The complexity of such an undertaking is staggering and proved extremely challenging to the international study centre co-ordinating it from the United States and the technical teams in Canada, Germany and all the national research co-ordinators in the countries. South Africa participated in TIMSS in 1995 (see Howie, 1996 and Howie and Hughes, 1997 for details) as well as in TIMSS-R in 1998 (Howie, 2000).

4.2 Design of TIMSS and TIMSS-R

The IEA's TIMSS-Repeat was a replication study that followed four years after TIMSS, in 1998. Several sources of data were collected through mathematics and science tests, questionnaires, performance assessment tests and a curriculum analysis project.

Three populations were tested in TIMSS and only one in TIMSS-R (Population 2). These are described as populations 1, 2 and 3. Population 1 comprises the students in the pair of adjacent grades that contained the most students who were 9-year-olds at the time of testing. Population 2 consists of students in the pair of adjacent grades containing the most students who were 13-years old at the time of testing. Finally, Population 3 includes students in the last year of secondary school, regardless of the type of programme in which they were enrolled (Robitaille and Garden, 1996). Mathematics and science curriculum-driven achievement tests were administered to students in Population 1 and Population 2, whilst mathematics and science literacy tests were administered to students in Population 3. The TIMSS design required that a minimum of 150 randomly selected schools be selected per population group. All participating TIMSS countries were required to participate in Population 2 with Populations 1 and 3 being optional, whilst in TIMSS-R only the upper grade of Population 2 was tested (usually being grade 8 in most countries).

The conceptual framework for TIMSS was derived from previous studies conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA). The IEA studies traditionally have recognised the importance of the curriculum as a variable for explaining differences among national school systems and accounting for student outcomes. These studies represented an effort to understand education systems and to make valid comparisons between them. The curricula and teaching practices of different national systems were investigated and compared with the student outcomes. These three factors became the focus areas for TIMSS. It was believed that differences in achievement could be explained in terms of variations in curriculum, teaching practices and other variables. It was also hoped that the study would help countries to evaluate national curricula and provide a research basis for future national curriculum reform.

South African sample

South Africa's sampling frame for TIMSS-R included 7,234 secondary schools with 968,857 students. In the first sampling phase, 225 schools were selected from all 9 provinces (the explicit strata). Additional implicit strata included the language of instruction (English and Afrikaans) and school funding (state, state-aided and private). Equal sample allocation was done by the explicit strata to produce regional estimates. Special explicit strata was also done in the Gauteng province to produce the schools required for the field trial conducted in English schools only. The national database of schools compiled by the HSRC for the National Department of Education in 1996 was used. For the second phase of sampling, information regarding the number of Grade 8 mathematics classes and students for the selected schools was collected. Thereafter the procedures for randomly selecting whole classes were performed according to the TIMSS-R guidelines resulting in one intact mathematics class per school being selected.

Instruments

In addition to achievement tests containing mathematics and science items, questionnaires were administered at the national and school-level at various times in the course of TIMSS-R. These were based on a review of the school, teacher and student factors shown in previous research to be related to student achievement. At school level, questionnaires were developed for the school principal, the mathematics teacher, the science teacher and the student.

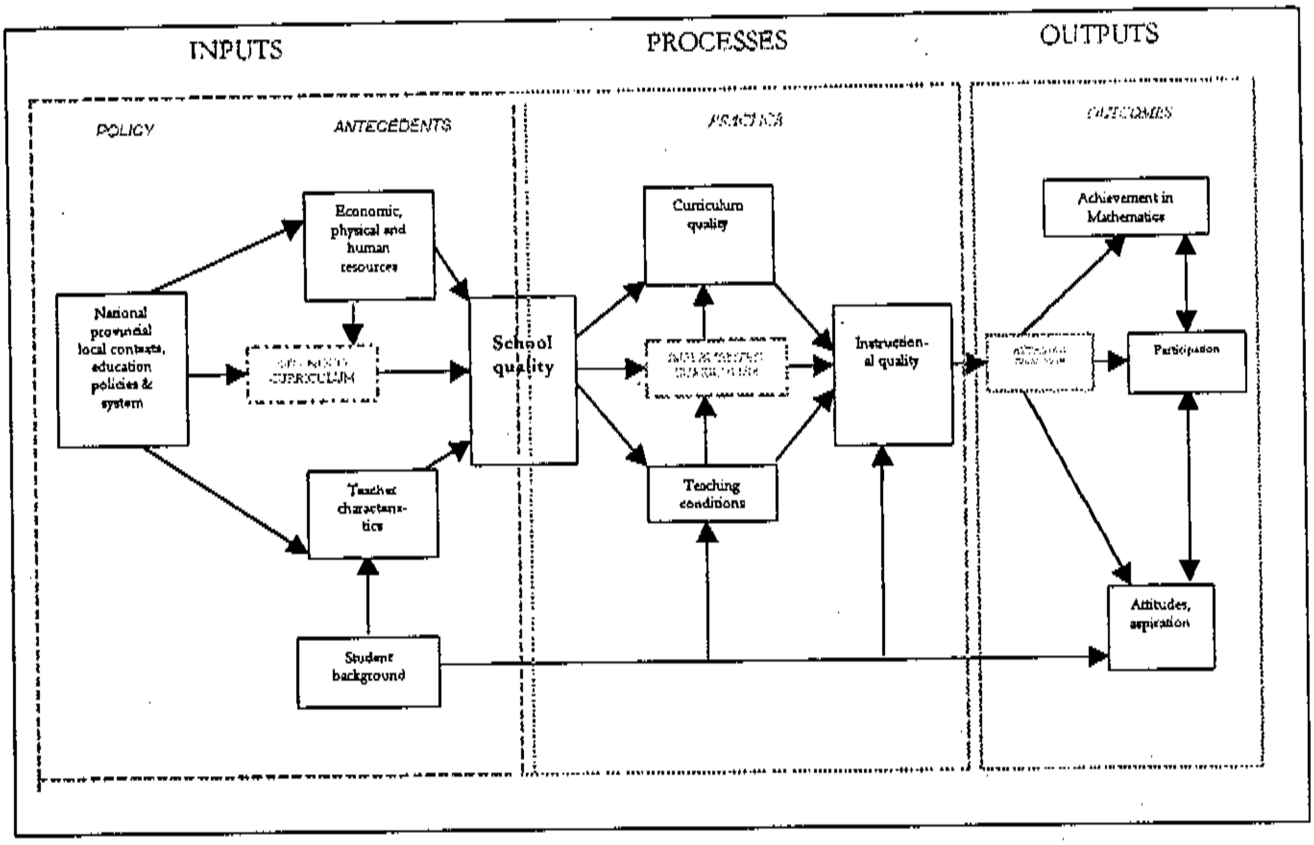
The teacher questionnaires sought information about teacher qualifications, preparation, the organisation and implementation of instruction with reference to a general lesson, homework, textbooks and other resources and views on issues in mathematics and science education. The student questionnaire collected demographic information, information on their out-of-school activities, their own and parents' expectations and attitudes towards school, mathematics and science. The school questionnaire was designed for the principal of each sampled school. The results from these questionnaires are expected to give one a good idea of the kinds of schools in the education system. Among the topics addressed in this questionnaire were enrolment, demographics and subject selection, as well as administrative, curricular, budgetary and social issues.

5. Design of this research

The conceptual framework presented in this section refers to the larger project mentioned in section 1. Nonetheless, it is highly relevant for discussion in this paper as a starting point for the analysis of the school-level analysis. As it is essential to understand the conceptual underpinnings of the model as a whole the model will be discussed in its entirety, although only briefly.

To monitor a dynamic system such as education, it is important to depict this in a way that, linkages between components of the system can be ascertained and evaluated. The model provided is based on the original framework by Shavelson et al (1987) who did a comprehensive review of the literature relating to social indicators and educational research. Furthermore, some of the IEA thinking on curriculum is reflected in the model. A number of adaptations have been made the original frameworks to better suit the research questions posed by this study.

Figure 5.1 Factors related to mathematics achievement
(Howie, 2000b, September 2000, adapted from Shavelson, 1987)



The model shown in Figure 1 presents the education system in terms of inputs, processes and outputs. In the model, the inputs are the policy-related contexts on a national, provincial and local level from which the intended curriculum is also designed and developed. The inputs also include the antecedents: the economic, physical and human resources supplied to different levels of the system; the characteristics of the teachers and the background of the students. The inputs into the system affect all the processes of education, which may also be seen as the practice in education. Different processes (relating to what is taught and how it is taught) take place within the districts, schools, and inside the classrooms in terms of the implemented curriculum, teaching (in the meaning of the context and conditions under which teachers work) and instruction. The outputs, also seen as the outcomes, eventuate in terms of the achievement of learners in specific subjects such as mathematics; participation in class and school activities and finally learners' attitudes towards subjects and schooling and aspirations for the future. It is expected that, due to the dynamics of the processes as shown in the model, there will also be indirect benefits and outcomes, such improved learner participation partly due to improved curriculum quality.

Looking at school-level, the focus of this paper, *School quality* includes aspects such as organisational management and development, governance, financial management, parent and community support, human resource management, instructional time, organised curriculum, school administration, effective support from district/education system, physical resources, school profile and schools' previous achievement. The intended outcome improved teaching is primarily evaluated through assessing the teaching quality. *Teaching quality* relates mainly to teaching load, class size, demands on time, teachers perceptions of working conditions, autonomy and collegiality. Information about the *curriculum quality* includes management of the curricula, instructional strategies, assessment and use of curriculum materials. *Instructional quality* on the other hand relates to issues such as instructional resources, policies, processes, activities, instructional climate, and teacher and learner interaction.

Aspects related to and impacting on elements of the system also impact on students' achievement although indirectly. Inputs in the education system includes contextual factors such as average class size in the district, economic factors such as annual per pupil operating expenditure, subsidies to schools, the average parent education attainment and annual per pupil capital expenditure.

The curricula for academic subjects play a central role in an education system. The IEA believes that the curricula are key in the evaluation of educational achievement. They differentiated between the intended, the implemented and the attained curriculum. In the model, its central positioning, and linkage between factors, within the model illustrate the key role of the curricula. The intended curriculum created through policies on education affects students achievement by outlining what the student is expected to learn and the teachers are expected to teach. The intended curriculum may occur both on system and school level. The implemented curriculum occurs also on two levels, namely at the school and classroom levels. Here the intended curriculum is interpreted by the school staff and organised on school and classroom levels. In particular, a further interpretation will be made by the individual teachers as to what is actually taught. The attained curriculum is reflected in the model as outcomes from the education system. These include the actual achievement of students in subjects, the level of participation by the students in classes and in school activities and finally is also reflected in terms of attitudes towards school, their school-work and the subjects in general, their peers and their teachers.

Other factors are also believed to influence achievement. From the literature, it is clear that antecedents such as student background (such as age, gender, home background and socio-economic conditions), and teacher characteristics (with similar information) also affect students' achievement.

The model serves as an important theoretical and conceptual basis for the analysis of the TIMSS-R data. As the data was collected on a number of education levels, namely, school, classroom and learner level, the model serves as a guide to explore the causal links for the learners' achievement.

5.2 Research methods

In order to explore the relationship and the effects of the different levels (and of the different variables) on students' achievement in mathematics, the main research project (on all three levels- school, class and student) is divided into two parts.

The first describes the South African students' performance in mathematics and will also provide descriptive information regarding the background characteristics of the students, their mathematics teachers and the schools that they attended. The second part is the exploratory phase of the study and the secondary analysis of the TIMSS-R data related to mathematics achievement. The data are explored to investigate the reasons for the students' performance described in phase 1 and to explore the inter-relationships of achievement and the background variables revealed by students, teachers and the school principal. In particular, the exploratory part of the study proposes to determine the factors that influence mathematics achievement and performance of South African students and to ascertain the influence of South African second language students' language and communication skills of on their achievement in mathematics. This exploration is intended to reveal a number of relationships between variables level that are open to manipulation on a student level, class and school level. Whilst it is recognised that some exogenous preconditions, which are factors external to the school (Brummelhuis, 1995: 15) (for example socio-economic variables) cannot be manipulated by the school, it is expected that there are a number of endogenous factors (on system-level and within the school or class) that may be manipulated. The intention of the study is to reveal those exogenous and endogenous factors through this exploration.

In this paper the descriptive data on school level from the school questionnaire is presented and the results of the first exploratory analysis on school-level is discussed.

5.3 Data Analysis

The data exploration aiming at identifying factors that influence achievement in mathematics in South Africa require scale and path analysis. The first step in the analysis plan was to produce univariates of all the possible school-, class- and student-level factors linked to the research questions and the data were explored to make constructs (such as possessions in the home) and thereafter to make a correlational matrix. In the descriptive phase bivariate and multivariate analyses were also done. These preliminary results are described in section 6.1. Principal components analysis and reliability analysis were carried out on sets of items referring to one factor or construct. Sets of items with a reliability coefficient Cronbach α of at least .50 were selected as composite variables. Thereafter, the correlational matrix was important to identify possible variables linked to achievement, to build constructs and to prepare a basic model for further analysis in second part of the research (see 6.3).

For the secondary analysis on TIMSS-R data, the PLSpath approach was applied. 'PLSpath' stands for 'Partial Least Squares path analysis' technique (Sellin, 1990, 1992). PLSPath version 3.0 was used in this research. This computer programme was developed by Sellin (1990) and is based on the Partial Least Square (PLS) procedure. PLS was introduced by Wold (1982) as a method for exploring relationships of independent variables by estimating path models with latent constructs measured by multiple indicators. PLS is a flexible and extremely powerful technique for the examination of path models with latent constructs measured by multiple indicators (Sellin, 1995:266). This is due to the fact that it can handle big datasets, it is technically easy to use, is very quick in computing the outcomes and finally does not require rigorous distribution assumptions. Since its development, many researchers have used it to analyse large datasets (Bos, (2000), Mahondas, (1999), Afrassa, (1998), Lietz, (1995), Sellin and Keeves, (1994) and Keeves, 1986 amongst others). Researchers such as Mahondas claim that PLS is very flexible in the initial analysis and that it gives satisfactory resultsAs the path model was developed post hoc (decisions concerning instruments and associated variables were made before the model was developed), the nature of the analysis is seen as more exploratory than confirmatory. The PLS technique was developed especially for research situations that require a great deal of exploratory analyses. In contrast, other approaches like LISREL and AMOS, were designed primarily for situations that require confirmatory tests of theoretically well-established path models. For more details of the PLSpath technique, publications of Sellin and Keeves (1994), Sellin (1990, 1992), and Wold (1982) are recommended.

Given that there are a number of variables influencing student's achievement and that some of these are intricately inter-related, Partial Least Squared (PLS) analysis was used initially to explore firstly the school-level factors. Thereafter in the near future, it will be used to analyse the student-level and classroom-level factors that influence students' achievement in mathematics.

Due to the fact that data was collected on three levels – student-level, class-level and school level, the Hierarchical Linear Modelling (HLM) will be used (this will be decided after the results of PLS are known) to distinguish between the variance in mathematics achievement uniquely explained by student-level factors as opposed to the variance uniquely explained by the classroom and school-level factors. As only one class per school was sampled, only two levels will be considered for the Hierarchical Linear modelling. As this stage has not been reached yet, only the preliminary results from the school questionnaire data related to the school-level model are included in this paper.

6. Results

6.1 Selection of School Quality items for analysis

A review of the school questionnaire revealed that almost all the items could be categorised under the component School Quality in the conceptual framework described in section 5. After examining the univariates combined with the literature review, the following factors were identified for further analysis:

Human resources (the number of teachers in the school),

Selection of students (admission procedures followed by the school to admit students),

Learning environment (percentage of student absent on an given day, the frequency of negative behaviour and the principal's perception of the gravity of this behaviour),

Principals' activities (these included activities related to instructional leadership, communication, administration and communication),

Parental involvement (schools' expectations of what parents should do at school)

First language (the number of students whose home language was the same as the medium of instruction in the school),

School enrolment (the number of students enrolled at the school),

Repeaters (the percentage of students repeating grade 8),

Class size (the average number of students across the grade 8 classes), *Grade size* (the number of students in grade 8),

Community (the location of the school: in isolated area or village, rural town, outskirts of a city and city centre),

Retention of the teaching staff (the percentage of teachers who have been at the school for longer than 5 years), *Limitations* (shortages of general facilities and learning equipment, shortages of maths-related facilities and learning equipment),

Autonomy of the staff in the school (responsibility for taking decisions – outside school, school governing board, school, heads of departments and teachers. The extent to which the staff at schools playing a role with regard to influencing the curriculum and specifically the role of teacher unions in influencing the curriculum implemented at the school).

The following section describes the univariates from which the factors described above were derived.

6.2 Profile of the schools in TIMSS-R

Number of teachers

The number of teachers varied markedly across schools. On average schools had 21 full-time teachers with the smallest school having one teacher and the largest teaching staff comprising 100 teachers. Few schools had part-time schools, the mean being 0.8 part-time teachers per school and the highest number of part-time teachers found was 25. Principals reported that on average 68% of their teachers had been at the school for 5 years or longer.

Number of students

The school enrolment was vastly different across the sample with the smallest enrolment being 44 students and the largest being 1957, typically representing a farm school in a rural area in the former and an urban school, the latter. On average schools had 854 students enrolled.

Average class size in grade 8

In South Africa, class sizes are generally larger than in most developed countries. In this sample, the average grade 8 classroom had 46 students in it, although the largest class found had 95 students.

Learning environment

As mentioned in section 3, the ethos in the schools has deteriorated over the past 25 years. Therefore it was no surprise to find that principals reported a relatively high incidence of negative behaviour in many schools and that in many cases they perceived this behaviour to be of a serious nature. These reports are summarised in table 6.1.

Table 6.1. ***Incidents of negative behaviour reported by the school principals***

Incidents of negative behaviour	Frequency of behaviour (n = 188)		
	Never or rarely	Weekly or Monthly	Daily
Theft	68	27	5
Intimidation of or verbal abuse of other students	60	29	11
Physical Injury to students	87	10	3
Intimidation or verbal abuse of teachers	90	9	1
Physical Injury to teachers	98	1	1
Illegal drug use or possession	82	9	9
Weapon use or possession	86	12	2
Inappropriate behaviour	92	7	1

In several cases, principals in South Africa reported a higher incidence of certain behaviours than was the case internationally, particularly with regard to the daily occurrence of theft, intimidation of students, alcohol abuse and drug abuse or possession. Evident is that 11% of the principals are dealing with intimidation and verbal abuse of other students by grade 8 students on a daily basis and nine percent are faced with problems of illegal drug use or possession by grade 8 students. Theft is reported as frequently occurring in a third of the schools as often as monthly, weekly or daily. Most shocking are reports of actual physical injury to teachers even though these are reported in only two percent of the schools, however more common is the intimidation or verbal abuse of teachers by grade 8 students reported by 10% of the principals.

Table 6.2 ***Hours spent by principals on different activities at school***

Instructional leadership	Communication	Administration	Teaching	Other activities not specified
19.5 hours	35 hours	18 hours	27 hours	9 hours

Principals were asked to estimate how much time was taken up by activities related to instructional leadership (discussing educational objectives with teachers, initiating curriculum revision and planning, training teachers and professional development activities); communication (talking with parents, counselling or disciplining students and responding to requests from district, provincial and national education); administration (hiring teachers, representing the school in the community, representing the school at official meetings and internal administration tasks) and teaching (including preparation) or giving demonstration lessons. Most of the principals' time was taken up by communication activities (35 hours). Principals also spent a considerable amount of time teaching (27 hours). In comparison, little time was spent on instructional leadership and administration.

Parental involvement

On the whole, schools expected parents to be involved in activities related to the school and related to their children's learning. Principals were asked to indicate what their schools expected from the parents. Most principals indicated that schools expected parents, to volunteer for school projects and programmes, to ensure that their children complete their homework, assist teachers with their trips, prepare food for children to take to school, serve on committees that select staff for the school and on those that review school finances. Most schools do not expect parents to notify the school about problems their child was having at home or with classmates, to raise funds for the school or to patrol the grounds of the school to monitor student behaviour.

Location of school

Half of the schools in the sample are based in rural areas with 3% of them being regarded as very isolated and 47% in rural towns or villages. Of the urban schools, 20% are on the outskirts of the cities and 30% in the city centres. A clear distinction was found in the results of the schools in these areas. The mean score of the rural schools was the lower than the urban schools, 225 and 227 compared to 287 and 328 points on a scale of 800 respectively).

Limitations

Principals were asked to report on the factors that they perceive affect instructional capacity of the school. Although they rated them affecting the capacity none (not at all), a little, some and a lot, Table 6.3 reports only none and a lot as well as the mean scores for each group.

Table 6.3 The extent to which the shortage of resources affects the instructional capacity of the school

Limitation	Extent of the limitation affecting the instructional capacity of the school % of principals			
	Not at all %	Mean score	A lot %	Mean score
General shortages of general resources				
Instructional materials (e.g. textbooks)	11	303	46	259
Budget for supplies (e.g. paper, pencil)	16	295	40	261
School buildings and grounds	21	289	40	255
Heating/cooling & lighting systems	20	284	42	246
Instructional space (e.g. classrooms)	27	277	32	247
Shortage of Mathematics related resources				
Computers for mathematics instruction	20	253	69	260
Calculators for mathematics instruction	20	296	47	251
Library materials relevant to mathematics	14	239	59	254
Audio-visual resources for mathematics instruction	13	247	64	250
Teachers qualified to teach mathematics	23	290	27	252

Regarding general resources, in all cases there is a clear difference between these two groups in achievement between schools reporting limitations and their achievement. Those that report that their schools are not affected by general shortages have a correspondingly higher achievement score in mathematics. However, the relationship is not so clear with regard to mathematics-related resources. This is the case for computers, library materials and audio-visual resources where the mean score for those reporting these not affecting their capacity was lower than reporting it affecting their capacity a lot. This seeming incongruous outcome is probably due to the fact that principals (from higher performing schools) reporting that they feel it affects their schools' capacity as well as the principals' (from lower performing schools) who do not perceive the value or linkage between those resources and their schools' capacity to deliver instruction in mathematics, answered the same answer category. Teachers of mathematics who actually experience the limitations first-hand would probably answer the same questions quite differently. The more obvious linkages to a school's capacity to provide instruction in mathematics, namely calculators and teachers of mathematics follow the same pattern as the reports under the general resources, that is that those without resources attain lower means scores.

Autonomy
Under this category, three items were investigated, namely who is primarily responsible for a number of activities in the school, secondly, the stakeholders within the schools' influence in determining the implemented curriculum at schools and finally, the extent of the teacher unions' influence in determining what is included in the implemented curriculum.

Table 6.4 Stakeholder responsibility at schools

Activities	Not a school responsibility	School governing board	Principal	Department head	teachers
Hiring teachers		X			
Establishing disciplinary policies		X			
Establishing student grading policies			X		
Formulating the school budget		X			
Purchasing supplies			X		
Placing students in classes				X	
Assigning teachers to classes			X		
Determining which textbooks are used				X	
Establishing homework policies				X	
Determining teacher salaries	X				
Establishing community relationships			X		
Communicating with students families			X		
Determining course content			X		
Deciding which courses are offered			X		

As can be seen from Table 6.4, most of the responsibilities for the executive functioning of the school lie with the principal. The heads of departments have a role with regard to the placing students in classes, determining the textbooks to be used and establishing policies. What is striking is the apparent absence of teachers, with regard to having responsibilities in the functioning on school level in the majority of schools. The growing number of schools installing school governing bodies is becoming more evident with the majority of schools reporting that these boards are responsible for hiring teachers, establishing disciplinary policies and formulating the school budget.

Influencing the implemented curriculum at schools

It appears that in most schools, individual teachers also have little influence with regard to the curriculum implemented at their school on school-level. Most of the influence seems to come from the provincial education department, although the principals report that they have some influence as do the department heads and the teachers collectively. As this interpretation has been made on data derived from the school principal questionnaire, the teacher questionnaire data will also be explored carefully to ascertain to what extent this is true on class-level as well.

6.3 Factors on school-level influencing achievement in mathematics

In order to prepare the data for model building, a number of preparatory steps need to be taken (Bos, 2000). First the descriptives and frequencies of all possible variables have to be analysed. As PLSPATH does not accept variables with missing values, these have to be replaced. As aggregated student level data was used (with regard to home language of students and mathematics scores) and then merged with the school-level data, a number of cases (n=10) were dropped where student-level data was not available. The final sample size was 189 schools in the sample. Once the missing values had been replaced, the correlation matrix is prepared and the factor analysis and reliability analysis is conducted for each variable in the model. In this next section, the reliability analysis (6.3.1) is described followed by a summary of the results of the correlational analysis (6.3.2), and thereafter a description of developing and exploring the model (6.3.3 and 6.3.4) and finally the results of the PLS analysis .

6.3.1 Reliability Analysis

A number of these factors were composites developed through a process of factor analysis (including principal component analysis) and reliability analysis. The reliability coefficients are given in Table 6.5 for each of the constructs described previously. If the Cronbach alpha coefficient was higher than .50, it was considered suitable for inclusion in the further analysis and is given in Table 6.5.

Table 6.5 Results of reliability analysis

Factor	Individual variables	Cronbach alpha
Selection	Admission procedures (13 items)	.75
Learning environment	Frequency of negative behaviour (9 items)	.87
Principal activities	Hours spent by principal on selected activities at school (14 items)	.51
Parental involvement	Schools' expectations of the extent of parents involvement in schools' activities (6 items)	.74
Limitations	Shortages of general resources (5 items)	:75
	Shortages of maths related resources (6 items)	.87
Autonomy	Responsibility for Decision-making in school (14 items)	.65
	Stakeholders influence of implemented curriculum (4 items)	.85

6.3.2 Correlational Analysis

After the reliability of all the constructs was tested, a correlation matrix was analysed. Each of the constructs and the other previously identified factors that are single variables were examined in relation to the mean mathematics scores. The results of this analysis are found in Table 6.6. Of the 15 factors, 13 of these were found with a coefficient of higher than 0.15, which was taken as the cut off point for inclusion in further analysis and as indications for direct paths to mathematics achievement.

Table 6.6 Correlation of background factors with mathematics score

Factor	Individual variables	Pcorr. Math score
Human resources	Number of teachers in school	.39**
Selection	Admission procedures (13 items)	-.09
Learning environment	Absenteeism	-.20**
	Frequency of negative behaviour (9 items)	.00
Principal activities	Hours spent by principal on selected activities at school (14 items)	++
Parental involvement	Schools' expectations of the extent of parents involvement in schools' activities (6 items)	.13
First language	Number of students in the tested class whose first language is the same as the medium of instruction	.58
School enrolment	Number of students enrolled in school	.28**
Repeaters	Number of students repeating grade 8	-.20**
Class size	Average number of students in grade 8 classes	-.22**
Community	Urban-rural community where school is located	.36**
Retention of teaching staff	% of teaching staff who have been in the school longer than 5 years	-.04
Limitations	Shortages of general resources (5 items)	-.18*
	Shortages of maths related resources (6 items)	-.19**
Autonomy	Responsibility for Decision-making in school (14 items)	-.10
	Stakeholders influence of implemented curriculum (4 items)	-.05
	Influence of teacher union on curriculum	-.22**

**significant at the 0.05 level, ** highly significant at the 0.01 level*

++ Not calculated due to large % of missing data (more than 15%)

No correlation was found between *selection* of students into schools, the reported frequency of negative behaviour (under *learning environment*, retention of teaching staff and stakeholders' influencing the curriculum (under *autonomy*). Furthermore, responsibility for decision-making in the school (under autonomy) and parental involvement had showed low correlations (-.10 and .13 only). The most highly correlated items with maths achievement were first language speaking students and the community where the school is located. The more first language speakers in the school, the higher the achievement score was. As this variable is also associated with socio-economic group status in South Africa this finding is to be expected. Students speaking English or Afrikaans are generally expected to come from more advantaged backgrounds than the majority of students speaking African languages at home. In addition to that, schools attended by the majority of first language speakers are considered privileged in their resources and generally have better facilities, equipment and more highly qualified teachers. It is important to note here that the exception to this would be the schools, which previously contained only Indian (typically having English as their home language in addition to Indian languages) and coloured (of mixed race) students (having either, English and Afrikaans as a home language). These schools would also have been disadvantaged under the old dispensation having poorer resources than former White schools, but generally slightly better than those of African schools.

The correlation between community and maths achievement indicates that the schools in the more urban areas produced better results than in rural areas. Again, this is perhaps not surprising as urban schools, on the whole, have better resources and attract students from more privileged backgrounds than rural students.

6.3.3 Developing a school model for mathematics

It is recommended by Falk (1987) that drawing a path diagram is helpful when starting to build a model using PLS. Therefore, prior to the analysis of the data, a hypothesised model, was compiled. This was done conceptually on the basis of what school-level factors could be expected (from the literature and knowledge of the context) to influence students' achievement in mathematics. It is hypothesised that a number of factors influence achievement directly (such as the number of repeaters in grade 8, the class size, parental involvement, the learning environment amongst others) whilst others also influence the achievement indirectly (such as school enrolment). Once the correlational analysis was completed, the factors were selected for inclusion into an initial model (a reduced hypothesised model). This initial model was tested using partial least square analysis.

6.3.4 Exploring the model using Partial Least Square Analysis

The first stage in model building is to draw the path diagram and thereafter the model is systematically trimmed. This involves eliminating the manifest variables and the latent variables, which do not have significant paths in the model (Beta coefficient less than .15). There are two parts to the model – the outer and inner models. The outer model specifies the relationships between the latent variable and the manifest variables, which either form or reflect the latent variable. The inner model indicates the strength of relationships between the latent variables. Five criteria are used for trimming the model and these are the weight, loading, communality, redundancy and tolerance (see Bos, 2000 for details).

6.3.5 Results of PLS model

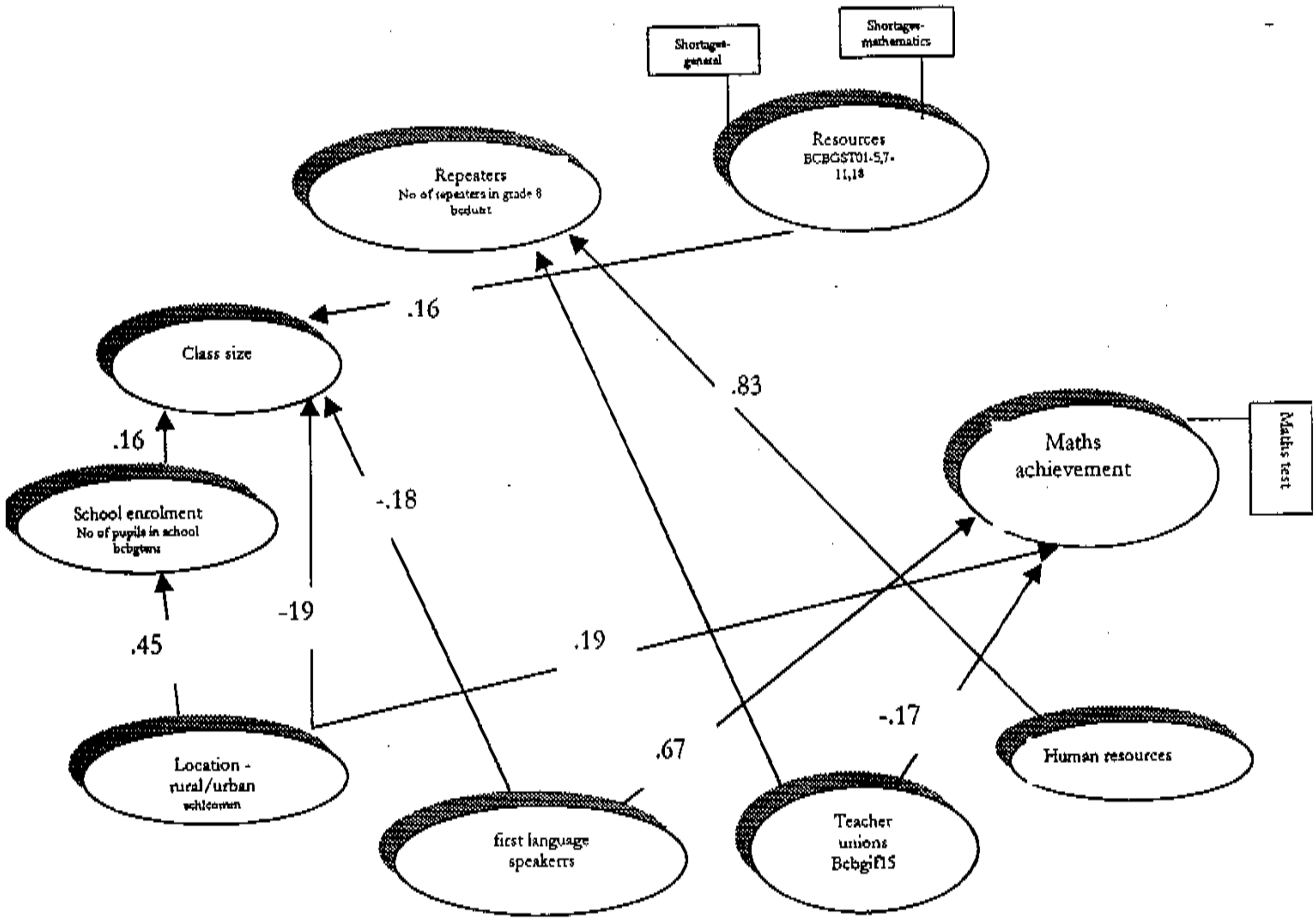
Ultimately, at this stage of the school-level model, only unities were entered into the outer model, meaning that a latent variable was reflected by a single manifest variable. Therefore the results given here only relate to the inner model which specifies the relationship between the latent variables.

Table: 6.7 Inner model results

Factor	Beta >.15	Correlation	R-squared >.10
Repeater			.69
Teachrat	.83	.83	
School			.21
Communit	.45	.45	
Class			.12
Communit	-.19	-.21	
Resource	.16	.20	
Firslang	-.18	-.22	
School	.16	.01	
Math			.62
Communi	.19	.41	
Union	-.17	-.25	
Firslang	.67	.74	

Table 6.7 shows that 62% of the variance in the student's achievement in mathematics (MATH) can be explained by the variables Community, Union and First language. The results indicate that students from schools in urban communities and students from schools where the students speak the medium of instruction at home are highly likely to do better in mathematics. Conversely, students in schools where teacher unions' are influential in determining what is taught are likely to perform worse in mathematics than students in schools where this is not the case.

Figure 6.1 Final model of school-level factors only



The number of repeaters at the school is greatly influenced by the teacher:student ratio with 69% of the variance being explained by this variable alone. Repeaters are highly likely to come from schools where the teacher: student ratio is high. The school size is influenced by the location it is in (21% of variance is explained). The larger schools are found in more urban settings. Class size is influenced by a number of factors. Those found include the location/community, the resources in the school, whether there are first language speakers and the size of the school. Only one variable (not given in the table) contributed indirectly to class size and that was Community (.07) by way of its effect on school size. The variance explained (seen by the R-squared coefficient in the table) is low and CLASS (.12) only just meets the criteria of .10 recommended by Sellin (1995) for smaller samples (such as 189). The larger classes are more likely to be found in rural communities, where there are greater shortages of general resources, where most of the students speak African languages at home and where the schools have high enrolment numbers.

CONCLUSION

When South Africa participated in TIMSS in 1995, only student–level could be analysed and therefore no profile of the schools could be generated within that study. Therefore the 1998 data permit researchers working with this data the opportunity for the first time to link different levels of data within a school together. At this stage of the research, only the school-level data was explored within certain constraints. One of these was the limitation of data available within the school questionnaire related to school quality. Nonetheless, some important aspects of school quality related to school leadership, parent involvement, school profile, physical resources, human resources, autonomy, learning environment and school administration were explored. Additionally, two important antecedents related to the type of community and the home language of the student were included in the model.

Although, this work is currently in progress, it is however clear that there are only a few variables on school-level identified as affecting mathematics achievement. These are largely factors beyond the control of the school (namely the location of the school and the home language of students) and therefore education planners and policy makers are not able to be manipulate these variables. Nonetheless, identifying these factors helps to explain the overall results and to alert those in authority as to the effect of these variables on students' achievement in mathematics. The influence of the location of the school in rural or urban areas on mathematics achievement is not surprising given the under-development in rural areas in SA. However, as 50% of South Africa's population live in rural areas, the fact that students attending school in rural areas perform worse in mathematics than those attending schools in urban areas should be of serious concern to the education authorities and policymakers.

Language problems are dominant in SA currently as policies relating to language are under development. The fact that there are 11 dominant recognised languages in the country presents certain logistical challenges for the education system (amongst others). Presently, English and Afrikaans are still considered the medium of instruction in the majority of schools. However, a key problem is that in most of the schools the language of instruction and the mother tongue of the teachers and/or the students are different. The result of this is that students' achievement in mathematics (and other subjects) is negatively affected, as can be seen from these results where first language speakers performed better. It should also be noted however that language is a confounding variable as it is also closely related to socio-economic status and schools with predominantly better resources. This will be further investigated in the larger research project.

A third factor identified as influencing achievement was that of the extent of the teacher union's influence on the curriculum, which was negatively related to achievement. Although the data suggest this relationship, caution needs to be taken with regard to the interpretation of this outcome. This is primarily due to the conclusion being drawn based on a single item in only the school questionnaire with little further interpretation possible from the original question asked.

Further investigation into school-level effects will continue as the teacher-level data (from the mathematics teacher questionnaire) is combined with the school-level data (from the school principal's questionnaire) to produce a single school and teacher level model. This is due to the fact that only one class per school was selected for testing as well as the fact that PLS is a uni-dimensional model. Additional variables from the maths teacher questionnaire that will be added to and tested include: Classroom resources, teachers' background, teachers' confidence, activities conducted by the teacher in the class, teachers' beliefs, maths topics coverage, homework, teaching style, classroom environment, medium of instruction in school, teachers' attitudes to teaching, time on task. Certain aggregated student-level data will also be included in the model such as: racial group, age, gender and socio-economic status.

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