DOCUMENT RESUME

ED 455 250 TM 033 051

AUTHOR	Howie, Sarah J.; Plomp, Tjeerd
TITLE	English Language Proficiency and Other Factors Influencing Mathematics Achievement at Junior Secondary Level in South Africa.
SPONS AGENCY	South Africa Univ., Pretoria.; Twente Univ. of Technology, Enschede (Netherlands).
PUB DATE	2001-04-00
NOTE	29p.; Paper presented at the Annual Meeting of the American Educational Research Association (Seattle, WA, April 10-14, 2001).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*English; Foreign Countries; International Studies; *Language Proficiency; Least Squares Statistics; *Mathematics Achievement; Second Language Learning; Secondary Education; *Secondary School Students
IDENTIFIERS	*South Africa; *Third International Mathematics and Science Study

ABSTRACT

South Africa participated in the Third International Mathematics and Science Study (TIMSS)in 1995 and its repeat in 1999. In 1995, none of the data on school or teacher level could be analyzed to provide the context for the students' poor achievements in mathematics and science. With the 1999 data now available at both school and teacher levels in addition to the student level data, this backdrop to the results can be provided. Path analysis, using Partial Least Square analysis, was conducted on the TIMSS repeat study (TIMSS-R) data to explore the effect of language and other factors at school level within South African schools on the students' performance in mathematics. The work is currently in progress, but the initial results already indicate the strong relationship between English language proficiency and South African students' achievement in mathematics. The first results from the school level analysis reveals a relationship between the location of the schools, the number of first language speakers in the class, and the role of teacher unions influencing the curriculum to pupils' achievement in mathematics. These and other results of this research are discussed in the paper. (Contains 3 figures, 10 tables, and 43 references.) (SLD)

AMERICAN EDUCATION RESEARCH ASSOCIATION ANNUAL GENERAL MEETING, APRIL, 2001, SEATTLE, USA

ENGLISH LANGUAGE PROFICIENCY AND OTHER FACTORS INFLUENCING MATHEMATICS ACHIEVEMENT AT JUNIOR SECONDARY LEVEL IN SOUTH AFRICA

SARAH J. HOWIE AND TJEERD PLOMP

AMERICAN EDUCATION RESEARCH ASSOCIATION ANNUAL GENERAL MEETING, APRIL, 2001, SEATTLE, USA

ENGLISH LANGUAGE PROFICIENCY AND OTHER FACTORS INFLUENCING MATHEMATICS ACHIEVEMENT AT JUNIOR SECONDARY LEVEL IN SOUTH AFRICA

SARAH J. HOWIE AND TJEERD PLOMP

Details of authors:

Sarah J Howie
Faculty of Education
University of Pretoria
Pretoria, 0002
South Africa

Tel: +27 12 420 2321
Tel: +27 12 362 5122
Email: Showie@postino.up.ac.za

Tjeerd Plomp
Faculty of Educational Science & Technology
University of Twente
Enschede
The Netherlands

Tel +31 53 489 3595
Fax: +31 53 489 3759
plomp@edte.utwente.nl

Abstract

South Africa participated in the Third International Mathematics and Science Study (TIMSS) in 1995 and its repeat in 1999[1] both under the auspices of the International Association for the evaluation of Educational Achievement (IEA). However, in 1995 none of the 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 1999 data now available at both school and teacher level in addition to the student level data, this backdrop to the results can be provided. Firstly the results of the student's performance in mathematics and English is given. Thereafter, questions on school level regarding the leadership of the school, the physical conditions within the schools, the students' behaviour, and the schools' expectations of parents were investigated in relation to mathematics achievement.

Path analysis (using Partial Least Square analysis) was conducted on the TIMSS-R data to explore the effect of language and other factors at school level within South African schools on the students' performance in mathematics. The work is currently in progress, however the initial results already indicate the strong relationship between English language proficiency and South African pupils' achievement in mathematics. The first results from the school level analysis reveals a relationship between the location of the schools, the number of first language speakers in the class and the role of teacher unions influencing the curriculum, to pupils' achievement in mathematics. These and other results of this research are discussed in the paper.

[1] Although South Africa actually collected its data in 1998 along with the Southern hemisphere countries, the study is referred to as TIMSS 1999 internationally and therefore this convention has been applied in this paper.

1. Introduction

At the end of the 20^{th} 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[2] 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. It is believed that as a result students' achievement in mathematics (and other subjects) is negatively affected. Research evidence (Joint Education Trust, 1998, Colvyn and Lebethe, 1998, Clarkson, 1991, Ellerton, 1991, Garden and Livingstone, 1989) suggests that language plays an important role in pupils' learning and that pupils learning in a second language may be disadvantaged. It is hypothesised therefore that pupils performing poorly in the English language test will also perform poorly in the TIMSS mathematics test.

This paper covers only part of a larger research project (Howie, 2000), that 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

[2] The integration of different race groups in former white, Indian and Coloured schools had been taking place since the abolition of the group areas act in 1990 and in private schools since about 1976, however it was after 1994, that this increased rapidly.

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.

This paper covers only the initial part of this exploration of the TIMSS-R data involving multivariate and multilevel analysis. Here the results of the English language test are given in addition to the overall TIMSS-R mathematics results. Furthermore, 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: a summary of the development of language policy and practice in education in South African is given in Section 2. Section 3 provides a brief overview of some of the literature dealing with school level factors and their relationship to achievement. Thereafter, a short description of the South African education context is given in section 4. Section 5 provides the reader with some background information on the TIMSS-R project. The research design is described in section 6 and includes the conceptual framework for the larger research project. Finally section 7 contains some of the results of the study and preliminary conclusions about the results to date.

2. Language policy and practice in South African schools

Like so much of South Africa's history, different policies were applied to different race groups. The policy in previously Coloured, Indian and White schools has stayed much the same since 1910 with English and Afrikaans (previously Dutch) being the official languages of the Union of South Africa. This meant that either English or Afrikaans was used as the medium of instruction with the second language being taught as a compulsory subject for all students. However, in 1948 when the nationalist party came to power, the policy changed and English and Afrikaans-speaking children were separated and sent to different schools where their mother tongue automatically became the language of instruction. Schools for Indians generally followed the English-speaking schools examples using English as the medium of instruction and offering Afrikaans as a compulsory subject. Coloured schools varied with some opting for English and others for Afrikaans as the medium of instruction and sometimes within one school both languages were used for instruction with students streamed for this purpose.

In African schools initially, either English or Afrikaans were used as the medium of instruction, with the majority of schools opting for English. However, the Nationalist Party's rise to power changed the policy and practice of language in education. Mother tongue was to be used for the first eight years of schooling (the whole of primary schooling) and English and Afrikaans became compulsory subjects from the first year of schooling. This change became the focus of the opposition to Bantu Education. With the introduction of and separate development of independent homelands and self-governing territories, the language policies evolved differently to the then government's expectations. These opted for mother tongue instruction in only the first four years of schooling from the 1960's and by 1974 all had decided (with one exception) on using only English as the official language of instruction from year 5 onwards. During the 1980's different options became available to parents of students at African schools as pupils could either start immediately with the medium of instruction to be used in the long term, or, have a sudden transfer from the mother tongue to a second language medium or, thirdly, a graduated transfer from the mother tongue to a second language medium. It would appear that the majority of schools adopted the first option of English as the language of instruction from Grade 1, although no audit has been conducted to substantiate the anecdotal evidence available.

The 1990's saw a multitude of policy documents on language-in-education. Although there was widespread consultation, there was also increased debate on bilingualism and multilingualism. In general, the policy documents promote the concepts of multilingualism. The importance of all South Africa's languages is stressed and at school level, the documents promote bilingualism at the very least but prefer that learners should learn at least three languages. The country's constitution asserts that the importance of "*creating conditions for the development and promotion of the equal use of all official South African languages*". The White Paper on Education and Training (1995) states that the "language in education policy must accommodate the right to be instructed in a language chosen by the learner, where this is reasonably practical". However neither the White Paper or the Department of Education's Language in Education Policy (1997) places any pressure on the schools to offer particular languages. They only encourage schools, which are "willing and able to offer more than one language medium in order to accommodate parental or learners' preferences". Ultimately the decision on the languages of instruction and those offered as subjects is left to the school governing bodies. The Schools Act (1996) stipulates that these bodies are required to "announce the schools' language policy and to state how it will promote multi-lingualism through a variety of measures.

The difficulty of this is that schools find themselves in a quandry as to how to introduce such changes with cuts in the education budgets, frozen posts and redeployment of teachers have left little space for schools to enter into new course directions. The absence of concrete implementation strategy from the government means in that in all likelihood, past practices will continue and the goal of a multi-lingual society will disappear.

One of the most noticeable changes after 1994, was the dramatic change in the demography of students at previously white, coloured and Indian schools. African-language speaking students from the townships poured into all of these schools, whilst many Indian and coloured 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 results of urbanisation, is that many students do not have an obvious primary language nor have the desire to identify with any one linguistic group (Pirie, 1984 and Brown, 1998). Instead many students speak a number of languages and in some townships like Soweto, develop a dialect made up of words from a variety of African languages, English and Afrikaans. However, it is also true that they may not be fluent in all of these languages or even truly fluent in even one language.

The multicultural communities created by the dissolving of Apartheid and increased mobility of families seeking upward mobility means that issues around language in education are complex. Effective instruction is dependent largely on good communication under-pined by competence by both teachers and students in the language of instruction. However, the reality is that this is a problem in the majority of schools where the language of instruction used and the mother tongue of the teachers and/or the students is different.

3. School level factors related to achievement

Research focusing on schools 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 in the United States of America 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 primarily conducted in developed contexts. Reynolds and Cuttance (1992) reviewed a number of studies and found only 8-15% of variance attributable to school factors. Most of the research done so far has been in the developed nations and largely in Western Europe and the United States of America.

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, 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. The variation in findings illustrates the importance of the context of the research.

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. Reynolds (1998:1279) claims 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 and the synthesis of the research outcomes revealed support for Reynolds earlier conclusion, namely that factors at classroom level correlate generally more highly with achievement than those at school level.

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. Multi-level 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.

4. Education in South Africa

Education in South Africa is compulsory and "free[3]" 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 enroled 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. The schools are either funded entirely by the state, or funded partly by the state (state-aided) or finally are funded privately. 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, many teachers in government schools, especially where there are non fee-paying parents, are faced with large classes. Only a small proportion of all learners (3%) in South Africa is enroled 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.

[3] However, schools are entitled and do ask parents to pay schools fees, but pupils whose parents claim that they are unable to pay may still attend the school and are constitutionally entitled to do so.

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. Many teachers are also not qualified to teach their subjects. Although 85% of mathematics teachers are professionally qualified, only 50% have specialised in mathematics (Arnott et al, 1996) and sometimes for no more than one year post school equivalent. These conditions apply especially in former Department of Education and training Schools and the former homelands, both of which catered for African pupils only.

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 enroling in these subjects, but that initially there has been a corresponding drop in the overall pass rate.

In 2000, out of a total of 741 388 full time and part time students writing matric[4], 57,9% of all the matriculants wrote the mathematics examination (429 263 candidates)[5]. However, only 45,1% of the candidates passed[6]. The national pass rate for mathematics had dropped in 1996, 1997 and 1998, but increased in 1999 by 1,3% and in 2000 it increased further by 1,7%. One of the reasons for the 3% improved pass rate (1999-2000) is that many weaker students (primarily repeaters) who should have written the matriculation examinations were denied access to the examinations in 2000 and secondly many students who in the past had taken mathematics on the higher grade (a more advanced level of mathematics) had opted to take it on standard grade (the most commonly taken and less advanced level) and therefore presumably achieved better results at this level. The conclusion that may be drawn though is that although nearly two thirds more students enroled for mathematics and wrote the examinations in 2000, only approximately 113 000 more students are going through the system successfully compared to 1993 and most of these at a lower level compared to those in 1993.

5. Background on TIMSS-R

5.1 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 1995, 41 countries (including South Africa), 15 000 schools and 500 000 students participated in over 30 languages. For more details on the South Africa's participation and results in TIMSS in 1995 (see Howie, 1996 and Howie and Hughes, 1997 for details).

5.2 Design of TIMSS and TIMSS-R

The IEA's TIMSS-Repeat was a replication study that followed four years after TIMSS, in 1999 (see Howie, 2000 for details on South Africa's 1999 results). One hundred and ninety tousand pupils participated in 6 000 schools in 38 countries participated. Tests were conducted in 34 languages. Several sources of data were collected through mathematics and science tests, questionnaires, performance assessment tests and a curriculum analysis project.

[4] A decrease of 4,2% (21 533) in the number of candidates compared to 1999.

[5] An increase of 271 562 students compared to 1993.

[6] This refers to the combined pass rate for higher and standard grade (the two possible options meaning a more advanced or less advanced level respectively).

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).

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.

5.2 South African sample

The South African sample in TIMSS-Repeat 1998 of 225 schools (including about 10 000 pupils). The TIMSS requirements stipulated that a minimum of 150 schools be tested and that a minimum of one class (preferably one whole class) per school be tested. The South African sample was expanded to 225 to accommodate the inter-provincial analysis required. The sample drawn is nationally representative and is stratified by province, school sector and medium of instruction. In total South Africa's sampling frame for TIMSS-R included 7,234 secondary schools with 968,857 students. Ultimately, more than 9000 students in 200 schools were tested however, after data cleaning, 194 schools and 8147 students were included in the international dataset.

5.4 Instruments

The following instruments were used in TIMSS-R: eight test booklets containing mathematics and science achievement tests, pupil questionnaire, mathematics teacher questionnaire, science teacher questionnaire, school questionnaire. All of the questionnaires were completed as far as possible on the day that pupils were tested. In addition, a National Option was included: an English language proficiency test specifically for South African pupils. This instrument had previously been validated by the Human Sciences Research Council and standardised for Grade 8 Second Language pupils in South African schools. Questions about language use were also included in the TIMSS-R pupils' and teacher' questionnaires, to ascertain the extent to which the pupils are exposed to English. They included pupils' home language, ethnic group, the language spoken predominantly by the pupils in the mathematics class, the language used by the mathematics teacher in class, media languages pupils are exposed to and the language of their reading materials.

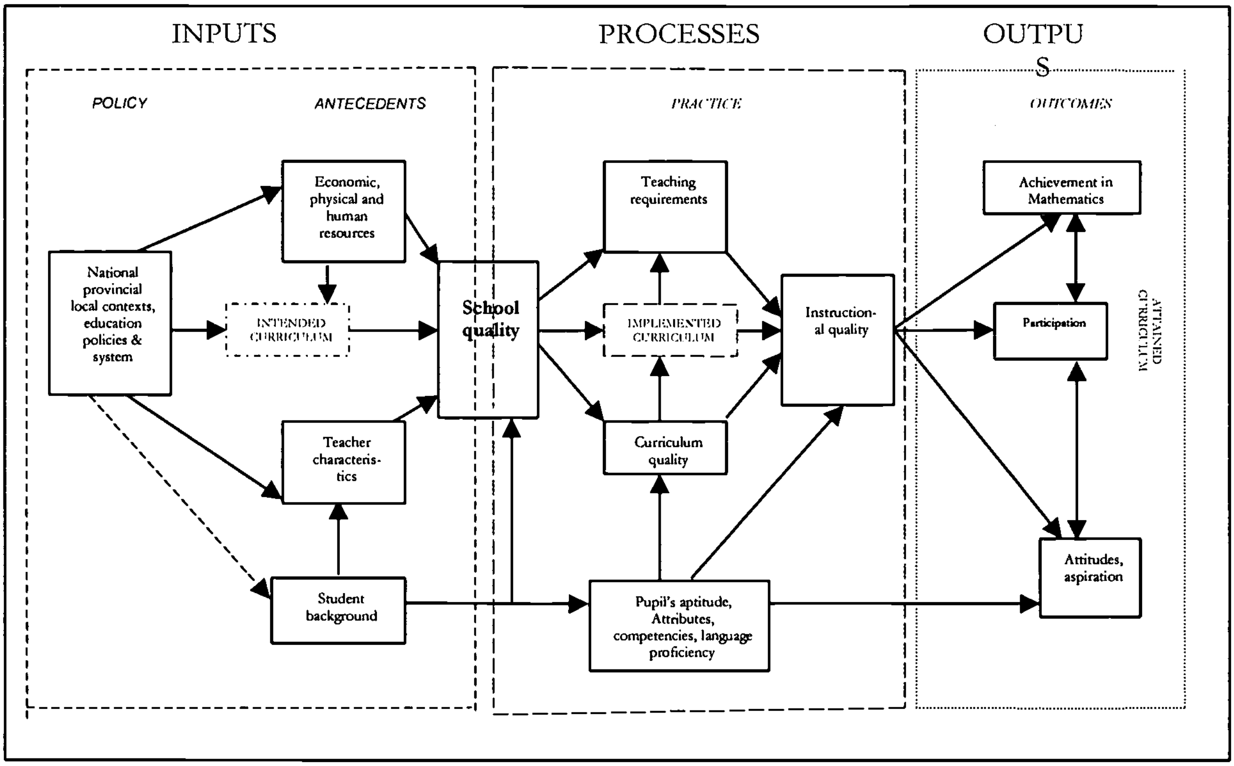
6. Design of this research

The conceptual framework presented in this section (6.1) 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.

6.1 Conceptual framework

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 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 as 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. *School quality* transcends both the Inputs as well as the Processes. This is because school quality comprises elements that are of a macro nature (and therefore are an input to the process on school level) as well as a number of factors that are typically found on school level and where schools may differ. *Teaching requirements* 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 selection of curriculum materials. *Instructional quality* on the other hand relates to teaching and learning activities in the classroom and includes issues such as instructional resources, instructional 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. For instance 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 (Figure 1), central positioning of the intended, implemented and attained curricula and their linkage between elements 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, further interpretation of the curricula is made by 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.

6.2 Research questions

The following research questions will be addressed in this paper:

1. *How does the performance of the South African pupils in mathematics compare with pupils from other countries?*

The mathematics results of all the countries participating in TIMSS 1999 will be compared with South Africa, including the subscales.

2. How do pupils from different language groups perform in the mathematics test?

In 1995, about 80% of the South African pupils wrote the test in a language that was not their main language and there were indications that this affected their performance negatively. In 1999, 74% of the pupils wrote the test in a languages that was not their main language.

3. How did pupils perform in the English Language proficiency test and how is this related to achievement in mathematics?

The extent of the pupils' aptitude in English is analysed and described. Every South African pupil completed a writing skills and language usage test which was a standardised test for second language speakers designed and developed by the Human Sciences Research Council in South Africa. The performance of the pupils in this test indicates a measure of language proficiency in English. In particular, the performance of pupils whose main language is not English but receive their instruction at school in English will be analysed. As language in South Africa is traditionally related to other important background variables due to the nature of the country's political past, other background variables will be explored and included in a model on pupil level.

4. what background variables on school-level are related to South African pupils achievement in mathematics?

Factors correlating with achievement will be identified and included into a PLS model for further analysis. Thereafter the most significant relationships willb e identified amongst the school-level variables and achievement.

6.3 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 language 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 in particular 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 with regard to mathematics and English are presented as well as the data at school level from the school questionnaire and the results of the first exploratory analysis on school-level are discussed.

6.4 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 the mathematics and English achievement data as well as all the possible school-level factors linked to the research questions and the data were explored to make constructs (such as mathematics resources in the school) 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 7.1. 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 results. As 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. In the near future, it will be used to analyse the student-level and classroom-level factors that influence students' achievement in mathematics.

In the larger project (and not included in this paper), due to the fact that data were 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.

7. Results

7.1 Performance of South African pupils in mathematics compared to pupils in other countries

7.2

TIMSS-R (as did TIMSS) used item response theory methods to summarise the achievement results. A scale of 800 points was used with a mean of 500 and a standard deviation of 100 points. Figure 2 illustrates pupils' achievement in mathematics from all 38 participating countries, giving the scale score out of 800 points. Countries are given in descending order of mean (average) achievement. The average scale score (with the standard errors), the years of formal schooling, and average age of the pupils are also presented.

<Insert Figure 2 Distribution of Mathematics Achievement about here>

South African pupils performed poorly when compared to all of the participating countries. The mean score of 275 (standard error [SE] 6.8) is well below the international mean of 487 (SE 0.7). This result is significantly below the mean scores of all other participating countries, including the two other African countries of Morocco and Tunisia as well as that of other developing or newly developed countries such as Malaysia, the Philippines, Indonesia and Chile. The achievement in mathematics was dominated once again by the Asian countries of Singapore (at the top with 604 scale points), Korea, Chinese Taipei, Hong Kong and Japan who achieved the highest scores.

The percentiles (see Figure 2) provide a perspective on the size of the differences between the countries. This is useful to review the performance of South African pupils on the international test compared to other countries. The top South African pupils (at the 95th percentile) were comparable to the below-average pupils from Singapore, indicating the vast difference between the two countries. This means that only the most proficient pupils in South Africa – and incidentally the same holds for Chile, Morocco and the Philippines – approached the level of the average pupils from Singapore. The South African pupils scoring around the country's mean fell below the least proficient pupils from almost all other countries with the exception of Morocco, the Philippines, Chile and Indonesia.

Virtually all the pupils participating in TIMSS-R had had eight years of formal schooling. There were a few exceptions. For example, some of the Australian pupils had received nine years of formal education, as had all the English pupils; pupils from Finland and the Philippines had received only seven years of schooling.

South African pupils, on average, were the oldest pupils in TIMSS-R as they were 15.5 years of age. This was significantly above the international average age of 14.4 years. The only other country where the average age was above 15 years was Lithuania (15.2).

7.2 Performance of South African pupils not speaking the language of the test at home

There was a substantial difference between the pupils who came from homes where the language of the test was always or almost always used (see Table 1). There was nearly 100 scale points difference between those who always/almost always spoke English or Afrikaans at home and those who sometimes did and an even greater difference between those never did. Similarly, there were large differences between the three groups for each of the sub-scales with the smallest difference in scores being observed in geometry. Overall and for each of the subscales, pupils who spoke English or Afrikaans at home performed better than those writing the test in an additional language.

Table 1 Mean mathematics overall scores and sub-scale scores of pupils who always, sometimes or never spoke the language of the test at home

	Always / almost always	Sometimes	Never
Mathematics score	360	263	231
Algebra	382	277	249
Data Representation, analysis & probability	406	352	327
Fractions & number sense	366	294	249
Geometry	374	326	321
Measurement	388	317	301

The low scores of the second language learners are most obvious when the pupils' scores on the test written in Afrikaans are compared to those who wrote in English. In South Africa, most of the pupils who speak one of the African languages at home would most likely attend schools where English is the medium of instruction and therefore they are learning in a "foreign" language. In contrast, pupils who attend schools where Afrikaans is the medium of instruction are most likely native Afrikaans speakers and would be white Afrikaners or Afrikaans-speakers of mixed descent (the coloured people). As can be seen below, most of the pupils writing the test in Afrikaans performed well above those writing the test in English. About 20% of the learners wrote in Afrikaans and once again the topic where the smallest difference in scores was found was in geometry.

Table 2 Overall mathematics scores and sub-scale scores of pupils writing the test in English and Afrikaans

	English	Afrikaans
Mathematics score	260	376
Algebra	275	398
Data Representation, analysis & probability	347	421
Fractions & number sense	285	380
Geometry	327	385
Measurement	318	397

7.3 Performance of South African pupils on the English language proficiency test

In general, the performance of the South African pupils on the English test was also poor. The mean score for all the pupils was 16 out of 40. The test however is considered reliable as the reliability coefficient was 0.81. What is immediately obvious is that the provinces whose pupils performed relatively better in the TIMSS-R mathematics test, namely, Western Cape, Gauteng and Northern Cape, also performed better in the English test. In the Western Cape and Gauteng, these areas are largely urban and therefore one might expect the pupils to be more exposed to English than those in some of the provinces comprising vast rural areas. However, one interesting aspect is that pupils in the Northern Cape, most of whom were primarily Afrikaans-speaking performed better than those in other provinces. The explanation for this relatively better performance may well lie at school level. The pupils from the Northern Province obtained the lowest overall mean scores in both mathematics and English. This largely rural province also has one of the highest unemployment rates, a very low socio-economic basis for most inhabitants and relatively few resources for one of the largest school-going populations in the country.

Table 3. South African pupils scores for the English test and the mean overall scores for the TIMSS 1999 mathematics test.

	Province	English	Maths	
		Mean score	Mean score	SE
1	Eastern Cape	15	256	11.8
2	Free State	16	266	20.3
3	Gauteng	21	326	22.7
4	KwaZulu Natal	16	271	17.3
5	Mpumalanga	15	247	15.2
7	Northern Cape	18	315	13.6
6	North West	16	267	12
8	Northern Province	14	229	4.7
9	Western Cape	21	376	20.7

A Pearson's correlation coefficient of 0.65 was found when testing the relationship between the mathematics and English test scores indicating a strong relationship between the two. Those pupils who achieved better scores in mathematics also tended to do so in English. Perhaps this link between the performance on the English test and that on the mathematics tests is explained by the fact that language plays an important role in the formulation and expression of concepts in mathematics. For instance, language is often meaningless to pupils when using it as their second language and this results in a lack of confidence and unwillingness by pupils in using the mathematics language (Colyn and Lebethe, 1998: 23). This is also because of the use of familiar words in unfamiliar contexts; the ambiguity of the language of mathematics; and the fact that learners informal language is much more developed and complex than their mathematical language which is further complicated by their poor grasp of the language of learning. Therefore, this has serious implications generally for the achievement of second-language speakers and in particular, for their performance in mathematics.

This was confirmed by the fact that there was a strong correlation between those pupils speaking the language of the test at home and their performance on the Mathematics (0.43) and English (0.45) tests. Those pupils who always or almost always spoke the language of the test at home were therefore more likely to perform better in mathematics and English. Conversely, the less that the pupils spoke the language of the test the worse their test scores in both mathematics and English. In particular, this indicates that the second language pupils, primarily many African pupils, performed poorly in both mathematics and English.

7.4 Contextual factors on school-level

As mentioned previously, the study sought explanations for pupils' achievement in mathematics and in this paper the first level investigated was the school-level. In this section, the preparatory steps as well as the results of the school level analysis are given.

7.4.1 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 6. 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 students 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 enroled 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. The scale analysis for the factors that are composites is discussed separately in 7.5.1.

7.4.2 Profile of the schools in TIMSS-R

Human Resources
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.

School enrolment
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 enroled.

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
The ethos in the South African schools deteriorated over the past 25 years, although there is some evidence that suggests that there is more stability in the last couple of years. However, 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 4. 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.

Principals activities

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.

Table 5 Hours as reported by principals spent by 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

Most of the principals' time they reported 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.

Principals' expectations of Parental involvement

On the whole, principals reported that they 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.

Community
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 reports only none and a lot as well as the mean scores for each group.

Table 6 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 of the staff in the school

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.

As can be seen from Table 7, 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.

Table 7 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		

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.

7.5 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 for South Africa was 189 schools. Once the missing values had been replaced, the correlation matrix was prepared and the factor analysis and reliability analysis were conducted for each variable in the model. In this next section, the reliability analysis (7.5.1) is described followed by a summary of the results of the correlational analysis (7.5.2), and thereafter a description of developing and exploring the model and finally the results of the PLS analysis in 7.5.3 .

7.5.1 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 8 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 8

Table 8 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

7.5.2 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 9. Of the 17 individual variables (clustered into 13 factors), 10 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 9 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.

7.5.3 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.

7.5.4 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).

7.5.5 Results of PLS model

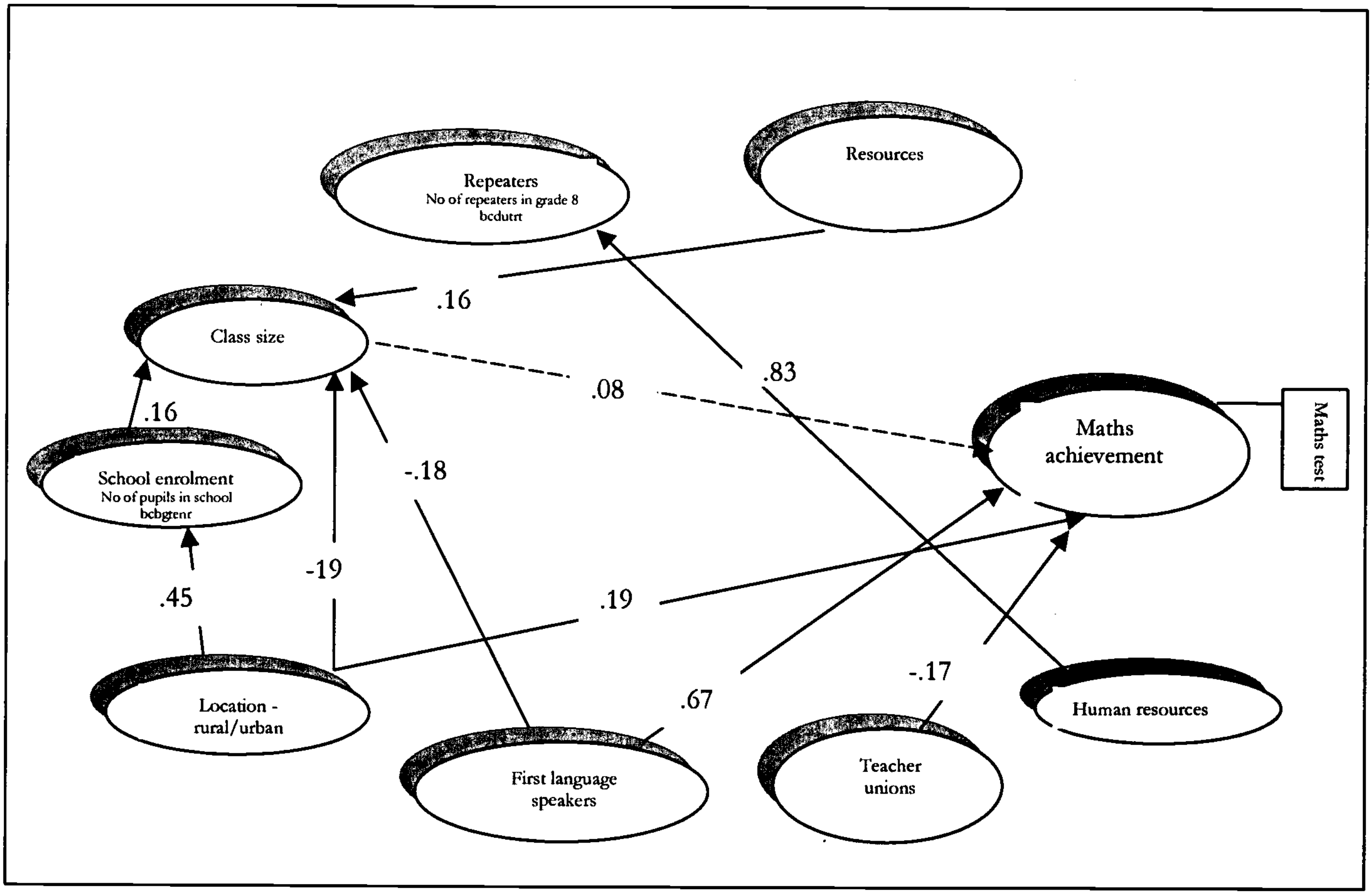
Ultimately, at this stage of the school-level model, only unities were entered into the outer model, meaning that a latent variable was reflected by a single manifest variable. Therefore the results given here only relate to the inner model, which specifies the relationship between the latent variables.

Table: 10 Inner model results of PLS

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 10 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 the 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. Although often quoted in the literature as influencing achievement, class size as seen in this model (Figure 3) has a very weak relationship (.08) with the mathematics score and therefore was not included in the table above, but was included for illustrative purposes below.

Figure 3 Final model of school-level factors only



As can be seen in the model, 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 and therefore teachers are dealing with larger numbers. The school size is influenced by the location it is in and 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 1999 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, the initial analysis of the English language data has been completed. However, only the school-level data (and not the classroom and pupil 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.

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 possibly other subjects) is negatively affected, as can be seen from the high correlations between language and mathematics achievements. From this study it would appear as pupils performing better on the English language test also performed better on the mathematics test. In addition the results on provincial level as well as in the school-level model indicate that the mathematics results were better where there was a larger number of first language speakers (both English and Afrikaans) in the class. 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.

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 but nonetheless need to be considered by education planners and policy makers. Furthermore, 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 South Africa. 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 and other authorities and policy-makers.

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.

References

Afrassa, T.M. (1998) Mathematics achievement in the lower secondary school stages in Australia and Ethiopia: a comparative study of standards of achievement and student-level factors influencing achievement. Unpublished PhD. Thesis, the Flinders University of South Australia, School of Education.

Beaton, A. E., Mullis, I.V.A., Martin, M., Gonzalez, E., Kelly, D. L., Smith, T. (1996a). *Third international mathematics and science study, mathematics achievement in the middle school years,* Boston: Boston College.

Bos, K.Tj. (2000). *Running PLS*. University of Twente. Unpublished paper.

Bos, K.Tj. and Kuiper, W.A.J.M. (1999). Modelling TIMSS data in a European comparative perspective: exploring influencing factors on achievement in mathematics in grade. *European Research and Evaluation. An international journal on theory and practice.* Volume 5, number 2. pp. 157-179.

Brown, D. (1998) *Educational Policy and the choice of language in linguistically complex South African schools*. Durban, Education Policy Unit, University of Natal.

Brummelhuis, A. C. A. (1995) *Models of educational change. The introduction of computers into Dutch secondary education*. Doctoral Dissertation, University of Twente, Enschede, The Netherlands, p.15.

Coleman, P.,Campbell, E.,Hobson, C.,McPartland, J., Mood, A., Weinfeld, F. and York, R. (1966). Equality of educational opportunity: Washington DC. National Centre for Educational Statistics.

Creemers, B.P.M. (1996). The school effectiveness knowledge base in Reynolds D. et al (eds) *Making good schools: linking school effectiveness and school improvement*. London: Routledge.

Crouch, L. and Mabogoane, T. (1998). When the residuals matter than the coefficients: an educational perspective in J. *Stud. Econ. Econometrics*, 22 (2).

Department of Education (1995) *White Paper on Education and Training*. Government Gazette, Vol. 357, No. 16312. Pretoria. Government Printer.

Department of Education (1997) Language in Education Policy. Government Gazette, Vol. 17997, No. 383. Pretoria, Government Printer.

Department of Education (1996) The South African Schools Act, Act 84 of 1996. Pretoria. Government Printer

Edmonds, R. (1979). Effective schools for the urban poor in *Educational Leadership*, 37, pp.15-24.

Falk, R.F. (1987). *A Primer for soft modeling*. Institute of Human Development, University of California, Berkley.

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

Heyneman, S.P. (1976). Influences on academic achievement: a comparison of results from Uganda and More industrial societies. *Sociology of Education*, 49, 200-211.

Heyneman, S. P. (1986). The search for school effects in developing countries: 1966-1986, *Monograph of the World Bank* (Seminar paper series, no. 33).

Heyneman, S. P., and Loxley, W. A. (1983). The effect of primary school quality on academic achievement across twenty-nine high- and low-income countries. *American Journal of Sociology,* 88 (6), 1162-1194.

Howie, (2000) *Conceptual framework: factors influencing mathematics achievement in South Africa*. Unpublished.

Howie, S. J., and Pietersen, J. J. (in press). Mathematics Literacy of Final Year Students: South African Realities. *Studies in Educational Evaluation.*

Howie, S. J., (1997) *Mathematics and science performance in the middle school years in South Africa: A summary report on the performance of the South African students in the Third International Mathematics and Science Study.* HSRC published report, Pretoria: Human Sciences Research Council.

Howie, S.J, and Hughes, CA. (1998). *Mathematics and science literacy of final-year school students in South Africa: Third International Mathematics and Science Study.* HSRC published report, Pretoria: Human Sciences Research Council.

Human Sciences Research Council (1997). *Schools needs based survey database*, HSRC Internal report, Pretoria: Human Sciences Research Council.

Husen, T. (Ed.) (1967). *International study of achievement in mathematics (Vol. 2).* Stockholm, Almqvist and Wiksell, and New York: Wiley.

Keeves, J. P. (1994*). The World of school learning. selected key findings from 35 years of IEA Research.* The Hague: The International Association for the Evaluation of Educational Achievement.

Keeves, J. P. (1986). Aspiration, motivation and achievement: Different methods of analysis and different results. *International Journal of Educational Research.*

Leitz, P.(1995). *Changes in reading comprehension across cultures and over time*, unpublished Ph.D Thesis, the Flinders University of South Australia, School of Education.

Mohandos, R. (1999). *Mathematics and Science achievement of Junior secondary school students in Indonesia*, unpublished Ph.D Thesis, the Flinders University of South Australia, School of Education.

Mortimore et al (1988)

Muller, J. and Roberts, J. (2000). *The sound and fury of international school reform: a critical review.* A report prepared for the Joint Education trust. pp.8,17.

Pirie, G. H. (1984). Ethno-linguistic zoning in South African black townships, *AREA* (19) 4.

Reynolds, D. and Cuttance, P. (1992). *School effectiveness: research, Policy and Practice.* London. Cassell.

Reynolds, D. (1998). World Class school improvement : an analysis of the implications of recent international school effectiveness and school improvement research for improvement practice in Hargreaves, A. et al (eds). *International handbook of Educational Change.* Dordrecht: Kluwer Academic Press. P.1279.

Riddell, A. (1997). Assessing designs for school effectiveness research and school improvement in development countries in *Comparative Education Review*, 41 (2), 178-204.

Robitaille, D. F.and Garden, R. A. (1996). *TIMSS Monograph #2: Research Questions and Study Design.* Pacific Educational Press. Vancouver.

Rutter , M., Maughan,B., Mortimore, P. and Outston, J. (1979) . *Fifteen Thousand Hours.* London: Open Books.

Scheerens, J. (1998). The school effectiveness knowledge base as a guide for school improvement in Hargreaves, A. et al (eds). *International handbook of Educational Change.* Dordrecht: Kluwer Academic Press, p.1110.

Sellin, N and Keeves, J.P. (1994) Path analysis with latent variables: In Husen, T and Postlethwaite, T. N. (eds). *International Encyclopedia of Education*, (2nd. edn). Pergamon, New York, pp.4352-4359.

Sellin, N. (1995) Partial Least Square Modeling in Research on educational achievement. IN Bos,W Lehrman, R.H.(eds) *Reflections on educational achievement: papers in honour of T. Neville Postlethwaite.* Waxmann, New York, p.266.

Shavelson, R. J., McDonnell, L.M. and Oakes, J. (1987). Indicators for monitoring mathematics and science education: a sourcebook. Rand Publications Corporation. Santa Monica.

West, M. and Hopkins, D. (1996) Reconceptualising school effectiveness and school improvement. Paper presented at the *American Educational Research Association Annual Meeting*, New York.

Wold, H. (1982). Soft Modelling: the basic design and some extensions. In K. G, Joreskog and H. Wold (eds.), *Systems under indirect observation* (part II, Chapter1). Amsterdam (the Netherlands): North Holland.

World Bank (1995). Priorities and strategies for education: A World Bank Review. Washington, D. C.: The World Bank.

Acknowledgements

Our thanks to the Universities of Pretoria and Twente for providing the funding to attend this conference. We would like to acknowledge the contribution of Drs Klaas Bos who contributed significantly to the development of path models and for sharing his experience on the scaling and path analysis to make this study possible and Dr Hans Pelgrum and Prof Jill Adler for their insightful comments on a previous draft of this paper. Finally, our thanks to Mrs Elsie Venter for her contribution to the data preparation and analysis and her long-term involvement with the data management of the TIMSS and TIMSS-R data.

AERA

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC

REPRODUCTION RELEASE

TM033051

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: English language proficiency and other factors influencing mathematics achievement at junior secondary level in South Africa	
Author(s): Sarah J Howie & Tjeerd Plomp	
Corporate Source:	Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1 [X]	Level 2A [ ]	Level 2B [ ]
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees end its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: Howie	Printed Name/Position/Title: Sarah J Howie (Mrs)	
Organization/Address: Faculty of Educational Science & Technology University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands	Telephone: +3153 4893595	FAX: +3153 4893759
	E-Mail Address: howie@edte.utwente.nl	Date: 13/4/2001

ERIC

(over)

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, *or*, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

University of Maryland
ERIC Clearinghouse on Assessment and Evaluation
1129 Shriver Laboratory
College Park, MD 20742
Attn: Acquisitions

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
1100 West Street, 2nd Floor
Laurel, Maryland 20707-3598

Telephone: 301-497-4080
Toll Free: 800-799-3742
FAX: 301-953-0263
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com