

A national assessment in mathematics within an international comparative assessment

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Abstract

South Africa has only recently introduced national systemic assessments at Grades 3, 6 and 9 into policy and conducted its first national assessment (Grade 3). Prior to this, South Africa had no systemic monitoring of the education system's quality apart from the results of matriculation examinations. Therefore when South Africa participated in the Third International Mathematics and Science Study (TIMSS) in 1995, it was the first opportunity for the country to gain a national overview of its learners'¹ performance as well as an international comparative perspective. South Africa also participated in the repeat of TIMSS in 1999 (TIMSS'99) and in both studies the performance was extremely poor compared with that of other countries. These two studies, both conducted under the auspices of the IEA (International Association for the Evaluation of Educational Achievement), provided an opportunity for South Africa to obtain a national assessment of their learners' performance in mathematics and science. Furthermore given the fact that the majority of learners are not educated in their home language, but in an alternative language, South African learners also completed a Language proficiency test in English in TIMSS'99, allowing researchers the opportunity to explore the relationship between English language and mathematics and science achievement. As background questionnaires are also administered to the students, teachers and school principals in IEA studies it is possible to explore the relationship between contextual factors on school, classroom and student-level and mathematics achievement. The research reported in this article illustrates the relevance of conducting national assessments, especially within the context of international evaluations of educational achievement.

¹ Learners and students are used interchangeably as required by the context, all referring to school-going children.

Partial Least Squares analysis was used to explore the relative contribution of these contextual factors to learners' achievement together with other background variables from the student, teacher and principal questionnaires. Thereafter multilevel analysis was employed whereby a 2-level model (school and class-level and the student-level) was analysed in order to investigate the main factors explaining achievement of South African learners in mathematics. The study revealed that a number of background variables on student and class-level were found to be significant. Amongst these the learners' proficiency in English was a strong predictor of their success in mathematics. However, home language and class size were among those that were not found to have significant effect on achievement, whilst the effect of socio-economic status (SES) had a lesser effect once certain class-level factors were taken into consideration.

Introduction

South Africa has no history of national assessments. It is only recently that the government has undertaken to institute regular samplebased assessments at for Grades 3, 6 and 9. Therefore, the Third International Mathematics and Science Study (TIMSS) conducted in 1995 under the auspices of the International Association for the Evaluation of Educational Achievement (IEA) (see Howie, 1997; Howie & Hughes, 1998) was the first opportunity for South Africa to gain a national overview of learners' performance in mathematics in grades other than Grade 12 where national examinations traditionally take place. In TIMSS the performance of the South African learners was significantly below those of pupils in all the other 40 participating countries in the study (Howie, 1997; Howie & Hughes, 1998). Learners in all three Grades (7, 8, 12) showed a lack of understanding of the mathematics and science questions as well as an inability to communicate their answers in instances where they did understand the questions. Learners performed particularly badly in questions requiring a written answer (Howie, 1997; Howie and Hughes, 1998).

TIMSS was repeated in 1998/1999 in South Africa and in 38 other countries and learners wrote tests in mathematics and science (Howie, 2002). These tests were written in either English or Afrikaans given their status as the official languages of instruction at the time of being administered. Given concerns arising from the TIMSS'95 study regarding the language proficiency of non-English speaking learners, learners in South Africa also had to write an English test, which was included as a national option. This article presents part of the final results of a three-year research project (Howie, 2002) exploring contextual factors at student and school level that have direct and indirect effects on learners' performance in mathematics utilising the national assessment data from the international dataset.

Objectives of the study

The research reported here compares the performance of South African learners with learners' performance in other developing countries that participated in TIMSS'99 and explores factors that have an effect on the performance of the South African learners in mathematics. These factors comprised background information that was also collected from the learners, teachers and principals of the schools included in the study.

The following research questions are addressed in this article:

1. How did South African learners perform in the TIMSS'99 mathematics test?
2. How does the performance of the South African learners compare with that of other countries?
3. Which factors at school level, class-level and student level have an effect on South African learners' performance in mathematics?

Literature review

A number of reports and articles have been written on the status of mathematics (and science) education in South Africa (for instance Arnott & Kubeka, 1997; Kahn, 1993; Taylor & Vinjevd, 1999). Many have bemoaned the poor results achieved in the mathematics matriculation examinations.

In 2001 the decision was made to introduce sample-based national assessments at Grades 3, 6 and 9 levels that would provide policymakers with information regarding the effectiveness of the education system. So far research conducted in South Africa that included achievement data, were case studies on local and regional samples (see Maja, Du Plooy, & Swanepoel, n.d; Monyana, 1996; Rakgokong, 1994; amongst others), resulting in limited inferences being made from the data. Most studies conducted to date were reported on the basis of classroom observations and discussions with teachers and other stakeholders. Only Monyana (1996) collected data for the purpose of analysing the factors that had an effect on mathematics performance and utilised inferential statistics, but this study was limited in scope. The Third International Mathematics and Science Study (TIMSS) conducted in 1995, provided the first national insight (with a nationally representative sample) into how South African learners were performing in mathematics (Howie, 1997; Howie & Hughes, 1998).

Internationally some research studies addressing factors related to achievement in mathematics were found using data from Australia (Afrassa, 1998), Belgium (van den Broek and van Damme, 2001), Ethiopia (Afrassa, 1998), Indonesia (Mohandas, 1999), Eastern Europe (Vari, 1997) and the Netherlands (Bos, 2002), with the majority being found in the USA (e.g. Sojourner and Kushner, 1997; Mullis, 1991; Mullis, 1992; Teddlie & Reynolds, 2000, amongst others). However, none was found in South Africa using a nationally representative sample.

Overall a mass of literature on factors influencing achievement was found internationally with the size of the studies varying greatly from case studies to large-scale surveys. Clearly there are many factors that have been found on **school-level** (see Cohn & Ressmiller, 1987; Creemers, 1996; Gray *et al.*, 1999; Mortimore, 1998; Sammons, 1999; Raphael, Wahlstrom & Mclean, 1989; Riddell, 1997; Teddlie & Reynolds, 2000; amongst others), on **class-level** (e.g., Arnott & Kubeka, 1997; Bradford, 1995; Chen, Clark & Schaffer, 1988; Cohn & Ressmiller, 1987; Ma, 1995; Martin, Mullis & Gregory *et al.*, 2000; Monyana, 1996; Mpofana, 1989; Mullis, 1991; Taylor & Vinjevd, 1999), and on **student-level** (e.g. Afrassa, 1998; Howie & Pietersen, 2001; Howie & Wedepohl, 1997; Martin, Mullis, Gregory *et al.*, 2000; Shen, 2000; Van den Broeck & Van Damme, 2001) to have positive or negative effects on mathematics achievement .

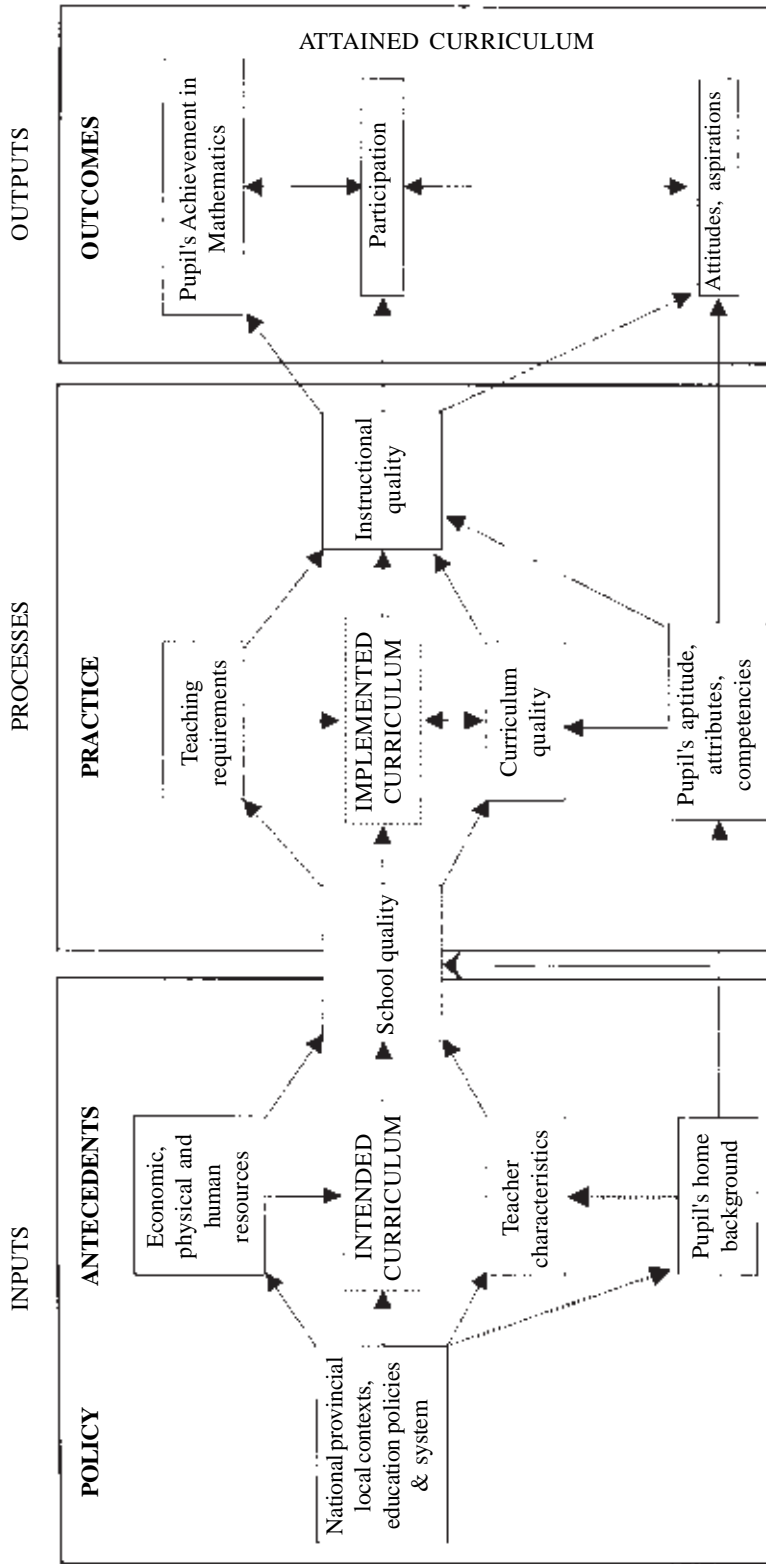
For a more comprehensive discussion of these factors and the literature refer to Howie (2002) and Howie (2003).

Theoretical framework

In order to address the objectives of the study, a conceptual model was developed for this research.

The model shown in Figure 1 presents the education system in terms of inputs, processes and outputs. The curricula for academic subjects play a central role in an education system. The IEA believes therefore that the curricula are keys to the evaluation of educational achievement. They differentiated between the intended curriculum ('what learners should learn and school should teach'), the implemented curriculum ('what is actually being taught in schools') and the attained curriculum ('what students actually learn'). In the model (Figure 1), the central positioning of the intended, implemented and attained curricula and their linkages between elements within the model illustrate the key role of the curricula.

Figure 1. Factors related to mathematics achievement



Howie, 2002, adapted from Shavelson, McDonnell & Oakes, 1987.

The model allows for the exploration of contextual factors within different levels influencing learners' achievement in mathematics within the context of South Africa. A summary of the model description is given here whilst a complete description can be found in Howie (2002).

The model was informed largely by Shavelson, McDonnell and Oakes (1987), as well as other literature referred to in the previous section. 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 learners. 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.

The model serves as an important conceptual basis for the analysis of the TIMSS'99 data. As the data were 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.

Research methods

The research reported here can be divided into two parts, namely a descriptive part and an exploratory and analytical part. Part one, addressing the first two research questions, concentrated on describing the South African learners' performance in mathematics and compared this with learners from other countries.

To explore what factors influence mathematics achievement and performance of South African learners an exploratory and analytical secondary analysis of the TIMSS-R data was conducted (research question 3). The data were first explored using Partial Least Squares (PLS) analysis to investigate the reasons for the learners' performance and to explore the interrelationships of achievement and the background variables revealed by learners, teachers and the school principal. As the path model was developed post hoc (decisions concerning instruments and associated variables were not made before the model was developed), the nature of the analysis is seen as more exploratory than confirmatory. After the PLS analysis multilevel modelling was applied to identify the factors that can be seen as the most important determinants of mathematics achievement in South Africa.

Sample

The study was undertaken using the South African sample in TIMSS'99. The data were collected by the Human Sciences Research Council based in Pretoria, South Africa. 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 interprovincial analysis required. The sample drawn was nationally representative and was stratified by province, school sector and medium of instruction. A two-stage stratified cluster sample of 225 schools was randomly selected and stratified according to province, type of education (government or private) and medium of instruction (English and Afrikaans). The realised sample comprised 200 schools and more than 8 000 learners to whom tests and questionnaires had been administered. Questionnaires were also administered to 200 school principals and 400 teachers of mathematics and science at Grade 8 level. For the purposes of this research, the data from 196 schools and 8 146 learners were utilised.

Instruments

The following instruments were designed and implemented for TIMSS-R: Eight test booklets containing mathematics and science achievement tests (comprised multiple choice and open-ended questions), student questionnaire, mathematics teacher questionnaire, science teacher questionnaire, and school questionnaire. Furthermore, an English language proficiency test was included specifically for South African learners as a National Option. This instrument had previously been validated by the Human Sciences Research Council and standardised for Grade 8 Second Language learners in South African schools. Questions were also included in the TIMSS'99 students and teacher questionnaires, to ascertain the extent and level to which the learners are exposed to English. They included learners' home language, ethnic group, the language spoken predominantly by the learners in the mathematics class, the language used by the mathematics teacher in class, media languages learners are exposed to and the language of their reading materials. In this research, data from the test booklets, learner questionnaires, mathematics teacher questionnaires, school questionnaire and the national option were analysed.

Data analysis

The first step in the analysis plan was to produce frequencies of all the possible school-, class- and student-level factors linked to the research questions. The data were explored to make constructs (such as possessions in the home) and thereafter a correlation matrix was made. A correlation matrix was drawn up to identify possible variables related to achievement, to build constructs and to prepare a basic model for further analysis. Given that there were a number of variables influencing learners' achievement and that some of these are intricately interrelated, Partial Least Squares (PLS) (see Sellin, 1989; Sellin, 1992) was used initially to analyse the strength and the direction of relationships between student-level factors and achievement and also those between classroom and school-level and learners' achievement in mathematics. PLS is a form of multivariate analysis that explores causal relations amongst different variables (factors) and represents these by means of graphic path diagrams. These diagrams or causal models illustrate the 'paths' along which the causal influences flow. This type of analysis allows researchers to estimate or predict both the direct and indirect effects of a set of independent variables on a dependent variable (with each path taking into account the effects of all the other variables). As PLS is only suited to analysing data on a single level (e.g. only student level data or only school level data) at any given time, PLS was followed by the application of multilevel modelling using MLwiN (Institute of Education, 2000) whereby both the school and class-level and the student level data were analysed simultaneously to identify and compare the overall effect of factors at different levels on achievement. Multilevel modelling is a research tool applying multiple regression analysis, that investigates the interaction between variables on the individual (student) level and variables that describe the social groups to which the individuals belong (e.g., schools and classrooms).

The fact that data were collected on three levels: student-level, class-level and school level, resulted in the multilevel modelling being applied. This would allow one 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 and to investigate the individual effects of variables inserted in the model once the multilevel structure of the data is taken into account. As only one class per school was sampled, only two levels (student level and the combined school and classroom level) could be analysed and this was due to the original TIMSS'99 design where class and school are considered one level.

Results

South African learners' performance in the mathematics tests

Overall South African learners achieved 275 points out of 800 (standard error, 6.8) in the mathematics test, whilst the international average was 500 (see Table 1). The province with the highest average scale score for mathematics was the Western Cape with 381 scale points, but this was still significantly below the international mean score of 487. The Northern Cape and Gauteng achieved the next highest scores with 318. Limpopo's was below all the other provinces with a score of 226.

Table 1: Mean scores for South African learners for mathematics across the nine provinces

Province	Number of learners	Mean Scale Score	Standard Error (SE)	Minimum score	Maximum score
1. Eastern Cape	932	256	11.8	15	594
2. Free State	901	276	20.3	5	574
3. Gauteng	605	318	22.7	51	647
4. KwaZulu-Natal	1228	292	17.3	5	612
5. Mpumalanga	963	253	15.2	5	601
6. North West	690	267	13.6	18	594
7. Northern Cape	728	318	11.8	52	608
8. Limpopo	1166	226	4.7	6.5	458
9. Western Cape	933	381	20.7	78	699
South Africa	8146	275	6.8	5	699

Howie, 2001.

The gender difference in the South African results was not statistically significant – the girls' scale score was 267 (SE 7.5) compared with the boys scale score of 283 (SE 7.3) resulting in a difference of 16 points. However, only in Western Cape were the girls' scores better in mathematics than those of the boys. In the Free State and the Mpumalanga provinces the boys perform on average 4-5% higher on the achievement test than the girls, although statistically there was no difference.

Table 2 reveals that the results of learners' scores with reference to the frequency with which the language of the test is spoken at home, appear to reveal a trend that learners who speak the language of the test more frequently also attain higher scores on the mathematics test. When comparing those learners who almost always or always speak the language of the test to those that never speak the language of the test, the former achieve scores that are more than 140 points higher than the latter.

Table 2: Mean mathematics scores for South African learners who always or almost always, sometimes or never speak the language of the test at home

	Always/almost always			Sometimes			Never			
	<i>N</i>	% of learners	Mean	<i>SE</i>	% of learners	Mean	<i>SE</i>	% of learners	Mean	<i>SE</i>
South African learners' score	8146	23	370	2.2	53	259	1.6	24	224	1.8

Mullis, Martin, Gregory *et al.*, 2000.

South Africa's performance compared with that of other developing countries

The overall mean mathematics score of South African learners 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 (see Mullis, Martin, Gregory, 2000). 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 with the top five scores.

The use of percentile scores provides a perspective on the size of the differences between the countries. This enables one to review the performance of South African learners on the international test compared with that for other countries. The top South African learners (at the 95th percentile) were comparable with the below-average pupils from Singapore, indicating the vast difference between the two countries. This means that only the most proficient learners 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 learners scoring around the country's mean (275) fell below the least proficient learners from almost all other countries with the exception of Morocco, the Philippines, Chile and Indonesia.

From a comparative analysis of South African learners' results with other countries in TIMSS-R (see Howie, 2001), some interesting observations were made. More than 70% of the learners from South Africa, Indonesia, Morocco, Philippines and Singapore did not always speak the language of the test at home. Nonetheless, the mean achievement scores vary considerably across this group of countries and there are also some interesting trends in the data. Learners in Malaysia generally did considerably better in mathematics than those from Indonesia. Nonetheless, there is a similar trend in both countries where pupils who never speak the language of the test at home, namely 9% in Indonesia and 10% in Malaysia, still appeared to outperform those who always or sometimes spoke the language of the test at home. It suggests therefore that the differences between language groups are not dependent only on language. Indonesia for instance is described as a highly diverse country with more than 600 languages and 200 million people (Baker & Prys-Jones, 1998) and yet apparently their pupils do not appear to have been as disadvantaged by writing the test in a second language. A similar pattern was also observed for Morocco and the Philippines in mathematics. In Singapore there does appear to be a difference as those who never speak the language of the test at home, still outperform pupils from 33 other countries.

Even looking at the other African countries, the scores for mathematics of those never speaking the language of the test at home are better than those of South African learners in the case of Morocco and are comparable with those from Tunisia. This issue needs to be explored further as it appears from the data that the pupils from other developing countries do not seem to be equally disadvantaged by writing tests in their second or third language in mathematics or science, however it is not clear from the data why this should be so. Important lessons may lie in the answers for South Africa.

Factors at student, classroom and school levels that have an effect on South African learners mathematics achievement

Three hypothesised models on student, class and school level were analysed using Partial Least Squares (PLS) analysis to explore the direct and indirect effects of individual variables at all three levels. The results of these analyses were scrutinised and thereafter the class and school level models were combined into one model and reanalysed. The main results are summarised here while the detailed explanation and discussion of these PLS results can be found in Howie (2002).

Student-level factors

Data pertaining to the learners' home background, their personal characteristics, their aptitude and competencies were explored. A high percentage of variance (50%) in the learners' mathematics score was explained. Six factors were found to have had a direct effect on South African learners' performance in mathematics, namely the learners' proficiency in English, their own self-concept in terms of mathematics, the language learners spoke at home, their socio-economic status at home, and whether or not they, their friends and their mothers thought that maths was important, and language of learning in the classroom.

School-level factors

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 in the data from the school principal's questionnaire. Two important antecedents related to the type of community and the home language of the learner were included in the model. Sixty-two per cent of the variance in the learners' scores in mathematics could be explained by three factors at the school level, namely, the community where the school was located, the influence that the teachers union has on the curriculum and an aggregated student variable, the extent to which the learners in the class spoke the language of instruction as their first language.

Classroom-level factors

From the mathematics teacher questionnaire, a number of classroom-level factors were also explored and this resulted in including the following factors in the model: teachers' gender, teaching experience, teachers' level of education, time spent on activities, lesson preparation, teaching load, time on task, teachers' attitudes, success attribution, teachers' beliefs, teaching style, resources, limitations, and class size. In total, this model explained 46% of the variance in the learners' mathematics scores by seven factors: the teachers attitudes, their beliefs about mathematics, the extent of their teaching and other workload, the size of the class they are teaching, their gender, resources and their dedication towards lesson preparation.

Combined school-class level factors

The school-level model and the class-level model were combined and the predictors of mathematics achievement were selected from both models and combined with four aggregated student-level factors into one model. Therefore factors related to teachers' characteristics, learners' home background, their aptitude, their attitudes, school quality, teaching requirements, curriculum quality and instructional quality were all explored in one model. Finally, this analysis resulted in six factors that were found to have strong effects on learners' achievement in mathematics and that explained 27% of the variance in the mathematics score. These were the location of the school, class size, the attitude of the teacher, teachers' beliefs about mathematics, the teachers' workload (including teaching) and their dedication towards lesson preparation.

From the Partial Least Squares analysis, the following factors were identified and included in the multilevel analysis: language learners spoke at home, socio-economic status (SES), learners' English test score, learners' own self-concept in terms of mathematics, whether or not they, their friends and their mothers thought that maths was important, language on the radio they most often listen to, size of the class the teachers were teaching, community where the school was situated, language spoken most often in the class by learners and teachers, teachers' beliefs about mathematics, attitude of the teacher towards the profession, teachers' dedication towards lesson preparation, teachers' teaching load and teachers' total workload. A final variable was included

because it was believed to be important from a political perspective, namely number of learners enrolled in a school. Ultimately 183 schools and 7 651 South African learners were included in the multilevel analysis. In the Null-model more than half of the variance is situated on the school level (55%) whilst 45% of the variance can be situated on student level. Only a summarised description of the multilevel analysis conducted can be given here. For more details on the MLnWin analysis and the results see Howie (2002).

In total, 11 of the 15 factors were found to be significant (where the p-value was at least $<.05$) predictors of South African learners' achievement in mathematics. Enrolment, class size, teaching time and home language are not significant. The most significant factor was the English test score and this was highlighted in the final extended model (see Howie, 2002, p.23) where the strength of the effect could be clearly seen. The data show that in the final extended model Socio-economic Status (*SES*) is no longer significant. The strength and significance of the school-level variables compensated for the student variables resulting in home language and *SES* losing their significance in the multilevel analysis.

In conclusion once all the predictors are added to the model, most of the school-level variance in learners' achievement scores (78%) could be explained in the full model. This is not the case for the student-level variance as a large percentage of the variance on student level (50% of the 45% in the null model), could not be explained by the predictors (including a number of language-related variables) used in this model. This may be due to the fact that other variables that are not included in this study are important as well. For example, cognitive ability was not measured in this study although this has been shown by Van den Broeck and Van Damme (2001) in Belgium to explain a great deal of variance on student level and to explain more than any other single variable in their multilevel model. More research is needed here.

However, the predictors did explain a high percentage (78%) of the variance between schools (see Howie, 2002). This means that a large part of the differences between schools in learners' mathematics achievement can be attributed to these variables. The full model indicates that significant predictors of how learners in different schools perform in mathematics are the learners' performance in the English test, the socio-economic status (to a lesser extent), the learners' self-concept, the learners' perception of the importance of mathematics, their exposure to English, how learners' maths teachers perceive their professional status, learners' maths teachers beliefs about mathematics, the location of the school, the extent to which English is used in the classroom, the amount of time teachers spend working and the amount of time teachers spend in lesson planning. They are also significant predictors of how well learners' perform in the same school (within-school variance), but to a lesser extent. Noteworthy is that two of these variables have a negative effect, teachers' perception of their status and their beliefs about mathematics. The stronger the teachers' ideas about mathematics and the perception about the status of the profession were, the poorer their learners performed in mathematics. This observation should not be looked at in isolation, but in conjunction with the other variables that have a significant effect on mathematics achievement.

Summary and discussion

The IEA's Third International Mathematics and Science Study (TIMSS 1994/1995) and its Repeat (TIMSS-R 1998/1999) had an unprecedented effect on mathematics and science education in South Africa. The study has been widely reported, studied and quoted in Ministerial and education policy circles as well as amongst academics, researchers and teachers in these fields. The South African learners' performance in TIMSS-R and its predecessor were discussed in a recent parliamentary report on improving the value of public expenditure in primary and second schooling in South Africa (Seekings, 2001).

South African learners performed significantly worse than those from all other participating countries in TIMSS-R including other developing countries. Despite the fact that Morocco and Tunisia as well as other developing or newly developed countries such as Malaysia, the Philippines, Indonesia and Chile participated, South Africa still underperformed in comparison.

In South Africa learners tended to achieve higher scores in mathematics when their language proficiency in English was higher and were more likely to attain low scores in mathematics when their scores on the English test were low. Those who spoke English or Afrikaans at home tended to achieve higher scores in mathematics. In contrast, children from homes where African languages were used were more likely to achieve lower scores. Learners from poor homes were also less likely to achieve high scores in mathematics as opposed to those from wealthier families, who were more likely to attain higher scores in mathematics. Learners who were in classes where the language of learning was mostly the previously official languages of instruction were more likely to achieve higher scores as opposed to those who were not. Better performance in mathematics tended to be found amongst children who came from homes where the mother believed that mathematics was important and where the child and their friends concurred with this. Learners much more likely to achieve higher scores in maths were those who had a strong self-concept in mathematics and did not find the subject particularly difficult, did not believe that they were not talented in maths, that maths was not more difficult for them than for their classmates and believed that maths is one of their strengths.

The influence of the location of the school in rural or urban areas on mathematics achievement is not surprising given the underdevelopment 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.

An interesting outcome was the strength of teachers' attitudes, beliefs and dedication as negative predictors of learners' achievement. Teachers whose learners were more likely to achieve lower results were those with strong mathematical pedagogical beliefs. These teachers believed that mathematics is primarily a formal way of representing the real world; that mathematics is primarily a practical and structured guide for addressing real situations; that if students are having difficulty an effective approach is to give them more practice by themselves during the class; that more than one representation (picture, concrete material, symbol set etc.) should be used in teaching a maths topic; that mathematics should be learned as sets of algorithms or rules that cover all possibilities; and that basic computational skills on the part of the teacher are sufficient for teaching secondary school maths.

This may mean that the teachers with stronger beliefs have less content knowledge and less understanding about the philosophy of mathematics perhaps due to their training or lack thereof. This may then result in teaching learners through rotelearning, while reporting in a way that reflects the philosophy of the new South African curriculum, namely learner-centred and problem-based teaching. On the other hand, teachers who had weaker beliefs may reflect a group of teachers who had good training, have a good content knowledge and have confidence in their preparation to teach, but stick to traditional teaching methods in contrast to those advocated by the new curriculum. Learners of such teachers tended to perform better on the TIMSS-R test, a test which has been criticised by proponents of realistic mathematics in the Netherlands as too traditional in its design and content. Further investigation of teachers' beliefs in relation to learners' achievement is needed. For instance, is it true that "weaker" teachers with stronger beliefs gave socially desirable answers in response to these questions? It may be possible that teachers who were trained in mathematics as a formal discipline subscribe to these beliefs as a result.

Teachers with feelings of being appreciated by society and their learners were more likely to produce learners with lower results. This could be due to the fact that these are teachers in more

rural areas who are highly regarded by their communities, as they are well educated compared with others in those communities. However, schools in these same communities are also poor and lack resources and learners come from poor homes and have much less exposure to the languages of learning and testing than their urban counterparts. So, although teachers feel affirmed, they are also challenged by the conditions in their schools, which results in learners attaining lower scores. On the other hand teachers who feel less affirmed work in better conditions in urban areas and where their learners come from different background.

Learners in classes where the learners and the teachers mostly interacted in the official media of instruction (English or Afrikaans) were more likely to achieve better results in mathematics. Teachers' commitment appears to play a key role in learners' performance. Learners whose teachers spent more time with work-related activities at school tended to achieve higher results in mathematics, although the amount of time that teachers spent actually teaching had no effect. Likewise, the amount of time that teachers spent preparing lessons resulted in learners being more likely to achieve higher results.

The lack of effect of class size as a predictor of achievement confirms previous findings in studies of developing countries (e.g. Afrassa). In the case of South Africa, those classes with large numbers of learners (on average 50 learners) are also those at schools with poor conditions described earlier and therefore it is possible that a type of bottom effect is felt here and therefore the effect of the actual number of learners is slight. These findings are significant against the background of the situation in many South African schools, particularly in those where there are African learners taught by African teachers. In these schools the conditions are the worst: limited resources and facilities, large percentages of underqualified teachers, learners from poor socio-economic backgrounds and instruction occur in a secondary language.

In conclusion the strength of the language component represented in a number of variables that have strong effects on mathematics achievement is clear. Moreover, the dedication of the teacher matters with regard to their learners' achievement while the location of the school is further an important predictor of South African learners' achievement in mathematics. In the past few years, some progress has been made to address shortcomings in South African schools. Although significant progress has been made with regard to administrative restructuring, policy development and infrastructural improvements, nonetheless the quality of education that the majority of learners is receiving is far from satisfactory. This study (Howie, 2002) highlighted the most significant predictors of mathematics (of which language is only one) within the scope of the data available. It has raised a number of questions and issues that are believed to be pertinent to the future development of South African education, in particular in mathematics. The challenges abound within the education system of this country and, in addition to the issues of access and equity, the most important challenge awaiting now is that of quality.

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