TIMSS R 1999 South Africa

Executive Summary

TIMSS-SA

Third International Mathematics and Science Study Repeat (TIMSS-R)

[redacted]

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Preface

When the results of the Third International Mathematics and Science Study (TIMSS) were first released nationally at a press conference in 1996, the shock of South African pupils' low performance reverberated around the country for quite some time. Although those in education were not surprised, there were intense debates in the media and in educational and political circles.

Since then, a number of national reports and articles have been written about South African pupils' performance in TIMSS. During this time, a number of policy-related and other activities have also occurred in mathematics and science education, which may or may not have had direct consequences for pupils' learning. TIMSS has certainly brought the issues related to mathematics and science education firmly to the attention of policy makers, and brought about a general awareness of the status quo of mathematics and science in the broader community, including business and industry. TIMSS was supposed to provide a foundation for policy makers, educational planners and managers, curriculum specialists and researchers from participating countries to understand the performance of their systems, and has contributed to the body of knowledge in South Africa.

TIMSS-Repeat was intended to measure the trends in achievement between 1994/1995 and 1998/1999. Four years is a relatively short time to measure such trends, but nonetheless policy makers and those involved in educational planning look for any such shifts as indicators of improvement. With so much happening in South Africa during this period, it is important to monitor the effects of these changes in education upon pupils' achievement in mathematics and science.

This report is intended to capture the key findings on a descriptive level, and to include information about pupils' achievement, the schools which the tested pupils attended, their mathematics and science classrooms and teachers, and some information about the pupils' home background. A number of international comparisons are made although the primary focus is on providing national information, including inter-provincial comparisons. This report serves to disseminate the key findings as widely as possible to all interested parties.

Of course a national project of this magnitude is not possible without the contribution of many people. I would like to take the opportunity to thank all the pupils, teachers and school principals who participated, as well as the provincial education departments. In addition, I would like to express my gratitude to the many individuals who contributed to the project and to this report: Vanessa Wylie, Elsie Venter, Collen Hughes, Palesa Moalosi, Peter Wedepohl, Tjeerd Plomp, Jacques Pietersen, Karin Pampallis, Ilse Vermaak, Hendrik de Kock, Brian Frankenstein, Andries Drost, Joe Lehutjo, Mmamajoro Shilubane, Nkhensani Mnisi, Badiri Moila, and the field workers. I would also like to thank members of the HSRC's senior management team – Andre Kraak, Mokubung Nkomo and Mark Orkin – for their support over the duration of the project. I am grateful to the international TIMSS centres in Boston, Ottawa and Hamburg for their technical assistance, guidance and leadership. Finally, I would to thank the IEA and the World Bank for their support and financial assistance, without which South Africa could never have participated.

Sarah Howie

National Research Co-ordinator of TIMSS-R in South Africa and HSRC project leader

CONTENTS

1. THE VALUE OF INTERNATIONAL COMPARATIVE STUDIES FOR SOUTH AFRICA

> For the first time in history international studies which indicate comparative standing in pupil attainment are conducted and taken seriously by governments (Taylor & Vinjevold, 1999:1).

This publication is the executive summary of the South African report on the Third International Mathematics and Science Study - Repeat (TIMSS-R) conducted in South Africa under the auspices of the International Association for Educational Achievement (IEA). TIMSS-R is a repeat of the Third International Mathematics and Science Study (TIMSS) conducted in 1994/1995. Thirty-eight countries (including Morocco, Tunisia and South Africa) participated in TIMSS-R, which focused on Grade 8. The study was undertaken in 1998/1999 to assess the developments that had occurred since TIMSS was conducted. South Africa's study comprised 8000 pupils and 200 schools, and was conducted by the Human Sciences Research Council (HSRC) in 1998. The HSRC funded the implementation of this study in South Africa, and its Group: Education and Training co-ordinated the study and administered the TIMSS-R tests and questionnaires to South African pupils.

An important question often asked is why these studies are carried out, especially in countries of limited resources, when they cost a relatively large amount of money. The usefulness of international studies can be categorised in terms of five broad areas of recipients of the information generated from such studies.

Firstly, the data collected at system, school, class and pupil level is being demanded by policy makers and decision makers world-wide. All are consumed with the drive to improve the effectiveness as well as the efficiency of their systems of education. As a result, international comparisons are assuming greater importance due to shared global economic realities; countries in very different situations can draw on similar solutions because of the similarity of reform goals such as promoting greater numbers of learners in the system, particularly in developing and newly developed countries (Young, 2000:1-2). Kellaghan (1996), Plomp (1998) and Postlethwaite (1999), from their analysis of previous IEA studies, believe that this system information and baseline data on pupils' achievement is essential for informed decision making on the development of curricula and the organisation and management of schooling. Such studies allow countries to compare national achievement between countries, to compare countries of special interest, to identify major determinants of national achievement country by country, and to examine to what extent the determinants are the same or different. From the rapid increase in comparative studies (not only the IEA with TIMSS and other studies, but also by the OECD and SACMEQ in the past three years), it is clear that the drive internationally for comparative empirical data is becoming stronger.

Secondly, teachers and other stakeholders at school level may learn from what is taught and how is it taught in other countries. There are a number of lessons that can be learnt about different management and organisation approaches as well as pedagogical approaches and processes at class level across the world.

Thirdly, researchers are exposed to the latest developments in research methodology (Beaton *et al.*, 2000) and capacity building in countries where no such opportunities previously existed (Howie, 2000; Ross, 2000). This type of research allows the world to be seen as a laboratory and gives exposure to examples of important analytical work (Postlethwaite & Ross, 1992; Keeves, 1996).

Fourthly, the community – and especially this generation of parents who have become increasingly involved in the education of their children – are entitled to know how the quality of education that their children receive in their own country compares to other countries around the world.

Finally, the consumers of the education system, namely the employers and institutions involved in further and higher education, should be aware of the products of the schooling system. This is essential so that education institutions are able to prepare appropriate learning programmes and employers can plan their recruitment and human resources training to meet the challenges of a global economy.

Aside from providing useful information as specified above, these international studies often serve to highlight the plight of education, especially in a country like South Africa where there are a host of other priority areas (such as health, poverty, AIDS, and rural development). The attention of various interest groups is drawn to the outcomes of such a large-scale study, which does not always happen with other research studies, regardless of their worth.

Of course, international studies take place within a context in each country. Therefore, before highlighting the key findings of the study, it is important to outline the activities that occurred in South Africa since TIMSS 1995 and prior to and during TIMSS-R 1998.

2. POLICY AND OTHER DEVELOPMENTS IN EDUCATION IN SOUTH AFRICA 1995-1998

No study takes place in a vacuum. The time between the two TIMSS projects in South Africa was a dynamic and sometimes volatile one in education, as several important policy initiatives were launched by the then newly elected government. Expectations in the country were high as "education for all" and free compulsory education were promoted. One of the first actions of the new government, started in 1994, was to amalgamate 19 different departments of education into one national and nine provincial departments of education. This was a very difficult operation given the disparity in physical and human resources, and was only completed after TIMSS was conducted in 1995.

The first White Paper on Education and Training in 1995 (Department of Education, 1995), was the first important policy paper providing a framework for the new system of education. This paper highlighted the importance of mathematics and science for the first time, and integrated education and training. One of the most challenging initiatives was the revision of the curriculum, which led to interim syllabi being used in schools from 1996. The developments around Curriculum 2005 continued to be challenged in the media and on other educational and political platforms;

although it was implemented in its pilot phase, it was not fully implemented in Grade 8 by the time of the test. While some of the terminology linked to the new intended curriculum was becoming widely known amongst the teaching fraternity it was not well understood. During this time, the White Paper on the Organisation, Governance and Funding of Education (DoE, 1996) was also released to provide a much needed basis for the distribution of resources across disparate schools.

A national teacher audit report was released (Hofmeyer & Hall, 1996) which, amongst other issues, highlighted the extent and size of the country's expenditure on teachers' salaries. The fact that more than 95% of the Department of Education's budget was being spent on teacher salaries (one of the highest proportions in the world) meant that there was virtually no money left for resources such as textbooks, equipment and building new facilities. This led to teacher retrenchments and redeployments starting in 1995. Ultimately, many teachers left the teaching profession, including many well-educated and experienced teachers in critical areas such as mathematics and science. This was accompanied by a nation-wide evaluation of the Colleges of Education in South Africa, which resulted in colleges being earmarked for mergers with higher education institutions, being reconfigured into community or technical colleges, or being closed. Many teacher educators were retrenched.

Another noteworthy initiative was the establishment of the South African Qualifications Authority (SAQA) in 1997 to implement the

National Qualifications Framework (NQF) that was intended to transform education and training – which is considered an extremely ambitious undertaking by many in the field of education.

Finally, the President's Education Initiative (PEI) was initiated in recognition of the need to address the problems linked to the challenges of the new system of education and of teachers in particular. This initiative comprised a number of phases and aspects. One of these was the commissioning of further research (35 projects in total) in which a number of projects drew on the baseline information collected by TIMSS in 1995. The reports from the research were submitted at the time of testing of TIMSS-R.

3. BACKGROUND TO TIMSS-R

The International Association for the Evaluation of Educational Achievement officially launched the Third International Mathematics and Science Study in 1994, although teams of researchers had been working since the early 1990s to prepare for the study. TIMSS was the largest and most ambitious international study of mathematics and science achievement at school level ever undertaken. Of the 63 countries that started the study, only 41 completed it. South Africa was the only country in Africa to do so. The Human Sciences Research Council conducted TIMSS among 15 000 South African students from more than 400 primary and secondary schools. South Africa's results from TIMSS 1995 can be found in Howie (1997) and in Howie and Hughes (1998). More information on the South African results in the first study can also

be found in the international reports by Beaton *et al.*, (1996a and 1996b).

In 1998, TIMSS was repeated (and is designated as TIMSS-Repeat or TIMSS-R), with tests and questionnaires administered in 38 countries. TIMSS-R was managed internationally by Boston College in the USA in collaboration with Statistics Canada in Ottawa (Canada), the IEA Data Processing Centre in Hamburg (Germany) and the Educational Testing Service in Princeton (USA).
The following countries participated in TIMSS-R:

Australia	Belgium (Flemish)	Bulgaria
Bulgaria	Canada Chile	ChineseTaipei
Cyprus	Czech Republic	England
Finland	Hong Kong	Hungary
Indonesia	IranIsrael	Italy
Japan	Jordan	Korea
Latvia	Lithuania	Macedonia
Malaysia	Moldova	Morocco
Netherlands	New Zealand	Philippines
Romania	Russian Federation	Singapore
Slovak Republic	Slovenia	South Africa
Thailand	Tunisia	Turkey
United States		

From the countries listed above, a selection was made that is considered of interest for comparative purposes throughout the report, namely Canada, Chile, England, Indonesia, Jordan, Malaysia, Morocco, Netherlands, Philippines, Singapore, South Africa, Tunisia, United States. While a small number of Western countries (and others where pupils performed well) were selected, an effort was made to select those developing and newly developed countries that might be of particular significance to South Africa.

TIMSS-R was conducted in South Africa by researchers from the Group: Education and Training at the Human Sciences Research Council. The South African TIMSS-R team consisted of three members and additional personnel were contracted for specific tasks (between 1997 and 1999) such as packing and organising the instruments, fieldwork, data handling, and management among others. In total over 220 people were involved directly with TIMSS-R in South Africa. More than 8 000 Grade 8 learners were assessed in 200 schools, and more than 350 teachers and 190 principals of those schools participated.

This publication focuses on South Africa's participation in TIMSS-R from both national and international perspectives. The aim of the report is to summarise the South African results for the mathematics and science tests and the background questionnaires, as well as to contextualise these results by providing essential background and technical information about TIMSS-R. More information about TIMSS-R can be obtained from the full national report (due to be published in February 2001), and from Mullis *et al.* (2000) and Martin *et al.* (2000). The national report will be followed by two others (one for mathematics and one for science) that will investigate in more detail the issues highlighted here, and provide a deeper analysis of TIMSS-R in South Africa as a whole.

4. DESIGN OF THE STUDY

4.1 Introduction

Four questions are central to the study:

- What are students expected to learn?
- Who provides instruction?
- How is instruction organised?
- What have students learnt?

Rather than including all three populations[1] that TIMSS studied, TIMSS-R only included pupils from Population 2, which in South Africa (and most other countries) is the first year of secondary school (Grade 8).

4.2 Instruments or tests

The TIMSS-R research collected three types of data:

- the curriculum,
- achievement, and
- contextual data from principals, teachers and pupils.

For the achievement tests, TIMSS-R used a rotation design, meaning that all test items were distributed across eight test booklets. The books were designed to be of equal difficulty and

[1] Populations 1, 2 and 3 were tested in TIMSS in 1995. Population 1 comprised Grades 3 and 4; population 2 comprised Grades 7 and 8; population 3 comprised Grade 12.

length and were supposed to be answered in 90 minutes. Test books were randomly distributed. Every pupil tested completed one test book and one questionnaire. All the instruments were modified for the South African context. This included adapting every instrument from American English to South African English (for example, *gasoline* to *petrol*, *tally* to *count*, *flashlight* to *torch*, *check* to *tick*), sometimes modifying the context (for example, changing dollars to rands, wolves to dogs, corn to maize, robin to bird, coat to shirt), and selecting more appropriate children's names (for example, *Chuck* to *Sipho*). Instruments were also translated into Afrikaans. The modified tests and questionnaires were verified by the IEA's verification centre who judged the translation process to be "excellently done".

The mathematics and science tests were developed internationally in a collaborative manner. Three different types of questions were included in the pool of TIMSS-R questions: multiple-choice questions, short answer questions and extended answer questions. (In TIMSS the short answer and the extended answer questions were grouped together as free-response items). Some of the items from 1995 were incorporated into the new tests as trend items, in order to measure the difference in achievement between 1995 and 1999.

Two questionnaires seeking information on national level curriculum plans, reforms, issues and policies with respect to mathematics and science curricula were administered to curriculum specialists. A school questionnaire was administered to the principal of each sampled school. The teacher questionnaires were designed for

the mathematics teachers and for the science teachers. TIMSS also developed a questionnaire for students, which included questions on the student's background, as well as their opinions and attitudes to mathematics and science. Included in the pupil and teacher questionnaires were additional questions specific to South African pupils and teachers. These questions focused mainly on issues related to language.

A total of 225 schools were selected from all 9 provinces. Within each province the schools were sorted by the language of instruction (English or Afrikaans) and school funding (state, state aided or private). For the second phase of sampling, one intact mathematics class per school was selected. Ultimately, 194 schools[2] and 8147 pupils were included in the international dataset for analysis. Excellent participation rates were attained in the Eastern Cape where 100% of the sample participated. KwaZulu-Natal and the Western Cape also recorded good participation rates. Unfortunately, the lack of co-operation from a number of schools in North West and Gauteng led to a considerably lower sample being reached in those provinces. While schools in the other provinces were generally enthusiastic about participating in the study, the schools in North West in particular (which had the highest number of non-participating schools, 9 out of 25) were reluctant to participate. In the end, South Africa achieved an 85% response rate and the national sample is considered representative for the country. Therefore, the information discussed in the report on a

[2] Actually 200 schools participated, but six schools were removed from the data because the principals had insisted on testing a different class to the one sampled, despite all efforts to the contrary.

national level can be generalised for the country. The provincial samples are also considered representative for each province, and therefore the results can be generalised for each province.

5. MATHEMATICS ACHIEVEMENT RESULTS

5.1 Overall national results

South African pupils performed poorly when compared to other participating countries (see Appendix A). The mean score of 275 (standard error, SE, 6.8) is well below the international mean of 487 (SE 0.7). The 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. As in 1995, pupils from the Asian countries of Singapore (at the top with 604 scale points), Korea, Chinese Taipei, Hong Kong and Japan demonstrated the best achievement in mathematics.

As can be seen in Appendix A, only the most proficient pupils in South Africa (and incidentally the same holds for Chile, Morocco and the Philippines) attained the level of the average pupils from Singapore. 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 8 years of formal schooling. There were a few exceptions; for example, some

of the Australian pupils had received 9 years of formal education, as had all the English pupils. This is a consequence of entering school at the age of five. Pupils from Finland and the Philippines had received only 7 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. However, South African pupils enter school at the age of seven years in contrast to the other countries where the entrance age is five or six years. The only other country where the average age was above 15 years was Lithuania (15.2).

The **International Top 10%** benchmark – that is, the average score achieved by the top 10% of pupils internationally – corresponds to a score of 616 out of 800. Very few South African pupils (less than 0.5%) reached this benchmark, in contrast to Singapore where 46% of their pupils did.

Only 1% of South African pupils reached the **International Upper Quarter** benchmark – the average score achieved by the top 25% of pupils internationally – which corresponds to a score of 555 (68% of the possible 800) points. This is a great contrast to the Asian countries where the benchmark was reached by more than 60% of pupils from Japan, Hong Kong, Korea and Chinese Taipei and 75% of Singapore pupils. The top 25% of South Africa's pupils achieved 337 out of 800 (42%).

Overall, the South African results appear very low in comparison to all the other countries participating in TIMSS-R, including the other two African countries, Tunisia and Morocco.

5.2 *Overall provincial results*

The province with the highest average scale score for mathematics was Western Cape with 381 scale points, but this was still significantly below the international mean score of 487. Northern Cape and Gauteng achieved the second highest score, with 318 each. Northern Province was below all the other provinces with a score of 226.

Table 1 Inter-provincial results for mathematics

Province	Number of pupils	Mean Scale Score	Standard Error	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 Northern Province	1166	226	4.7	6.5	458
9 Western Cape	933	381	20.7	78	699
South Africa	*8146*	*275*	*6.8*	*5*	*699*

An important finding is that the gender difference in the South African results was not statistically significant – the girls' scale score was 267 (SE 7.5) compared to 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 the boys. Provinces where relatively large (but not significant) differences appear and where the boys perform on average 4-5% higher on

the achievement test than the girls are Free State (34 points) and Mpumalanga (38 points).

5.3 *Results in content areas*

South African pupils' performance was relatively low in every content area (from 37% for algebra to 45% for data representation, analysis and probability). For South Africa, the average score for data representation, analysis and probability is the highest in that the score of 356 (SE 3.8) makes this the scale with the smallest difference to the international average. Ironically, this is also the area not included in the intended curriculum at Grade 8 level. The lowest achievement relative to the international average is in the area of algebra with a score of 293 (SE 7.7).

A detailed analysis shows that pupils have trouble with the interpretation of tables, figures and illustrations. They struggle with complex questions requiring more than one step and appear unable to express themselves in writing. Difficulties were noted where pupils were required to comprehend word problems and to articulate their answers and solve problems in writing. Pupils also had considerable difficulty dealing with fractions and with geometry questions regarding calculating "area". In general, when faced with multiple choice questions pupils resorted to guessing the answer and in some cases were successfully distracted by questions testing misconceptions. Pupils on the whole were unable to communicate their answers in the language of the test and they lacked the basic mathematics knowledge expected at the Grade 8 level.

6. SCIENCE ACHIEVEMENT RESULTS

6.1 *Overall national results*

South African pupils also performed poorly in science when compared to all participating countries (see Appendix B). The mean score of 243 (SE 7.8) is well below the international mean of 488 (SE 0.7). The South African results for science are significantly below the mean scores of all other participating countries, including the two other African countries of Morocco (323) and Tunisia (430) as well as that of other developing or newly developed countries such as Malaysia (492), Indonesia (435), Chile (420) and the Philippines (345). Four Asian countries – Chinese Taipei (569), Singapore (568), Japan (550), and Korea (549) – joined Hungary (552) in demonstrating the best performance in science.

The top South African pupils averaged 504 points. This was comparable to the bottom 25% of pupils from Chinese Taipei, Singapore and Japan, indicating the vast difference between South Africa and other countries (see Appendix B). This means that only the most proficient pupils in South Africa (and incidentally the same holds for Morocco) approached the level of the lowest achieving pupils from Chinese Taipei, Japan and Singapore. The South African pupils scoring around the country's mean fell below the least proficient pupils on average from most countries with the exception of Morocco and the Philippines.

The **International Top 10%** benchmark corresponds to a score of 616 out of 800 and is the point where the top performing pupils can be found. Less than 0.5% of South African pupils reached this benchmark (as did pupils from Tunisia and Morocco), in contrast to Singapore and Chinese Taipei where 32% and 31% respectively of their pupils did.

Overall, the South African results are very low in comparison to all the other countries participating in TIMSS-R, including the other two African countries of Tunisia and Morocco. A matter of great concern are the very low marks of the bottom 5% where the average is 53 points (meaning that these pupils scored on average 7% on the science test). This did not happen in any other country and the next lowest national averages were Morocco with 147 points and the Philippines with 144 points.

6.2 *Overall provincial results*

As for mathematics, the province with the highest average score for science was Western Cape with 393 scale points (see Table 2). This was significantly above the national average and above the mean scores of all other provinces. However, it was still significantly below the international mean score of 488. Gauteng achieved the second highest average score with 312, followed by Northern Cape with 283. Northern Province obtained the lowest average score (169), which was about half the score achieved by pupils from Western Cape.

Table 2 Inter-provincial results for science

Province	Number of pupils	Mean Scale Score	Standard Error	Minimum score	Maximum score
1 Eastern Cape	932	206	15.4	5	621
2 Free State	901	255	27.3	5	625
3 Gauteng	605	312	29.9	5	716
4 KwaZulu-Natal	1228	258	24.6	5	640
5 Mpumalanga	963	232	19.7	5	737
6 North West	690	235	19.8	5	619
7 Northern Cape	728	283	18.9	5	720
8 Northern Province	1166	169	4.7	5	439
9 Western Cape	933	393	22.8	10	775
South Africa	*8146*	*243*	*7.8*	*5*	*775*

The difference in the South African results for girls and boys was not statistically significant. The girls' average scale score was 234 (SE 9.2) compared to the boys' average scale score of 253 (SE 7.7). Internationally, the scale score average of girls was 480 (SE 0.9) compared to boys with 495 (0.9) and revealed a significant difference between the two groups with boys performing better than the girls. Similar to mathematics, substantial differences can be seen in Free State (51 points) and Mpumalanga (42 points) where boys achieved on average 5-6% more on the test than the girls did. This may be because there is greater encouragement for boys when it comes to science subjects and the fact that in many homes girls have household jobs to do when arriving home after school and don't have the time to complete their homework.

6.3 Results in content areas

Six content areas were identified by TIMSS-R for this international comparative assessment: Earth Science, Life Science, Physics, Chemistry, Environmental and Resource Issues, and Scientific

Inquiry and the Nature of Science. The topics for each content area are listed below:

- ***Earth Science:*** earth features, earth processes and the universe
- ***Life Science:*** includes diversity, organisations and the structure of living things, live processes and systems enabling life functions, life spirals, genetic continuity and diversity, human biology and health
- ***Physics:*** Includes efficiency, phase change, thermal expansion, properties of light and gravitational force
- ***Chemistry:*** includes classification and structure of matter, physical and chemical properties and chemical transformations
- ***Environmental and Resource Issues:*** Includes pollution, conservation of land, water, and sea resources, conservation of material and energy resources and effects of natural disasters
- ***Scientific Enquiry and the Nature of Science:*** Includes the nature of scientific knowledge, the scientific enterprise, and the interaction of science, technology and society

South African pupils' performance was low for each content area. The smallest difference between the South African and the international means was found in Chemistry and Environmental and Resource Issues (350 compared to 488). Within each content area a wide range of achievement was found; internationally, the largest range in achievement was found in Physics where Singapore achieved 570 points and South Africa 308 points, a difference of

262 points (39%[3]). The smallest variation in scores was found in Earth Science where Hungary achieved 560 points and South Africa 348 points, a difference of 212 points (26%).

Although there were no significant differences between the performance of South African boys and girls in TIMSS-R overall science scores, statistically significant differences were found in two content areas – Earth Science and Physics. On average South African boys scored about 3% more for Earth Science and 5% more for Physics than the girls. Internationally, significant differences were found for four of the 6 topics – Earth Sciences, Physics, Chemistry, and Environmental and Resource Issues. However, in Scientific Inquiry and the Nature of Science, 24 out of 38 countries had girls with higher averages than boys. It is interesting to note that girls appear to achieve higher scores on topics which are general in nature.

As in mathematics there were different types of questions in the TIMSS-R science tests, namely multiple choice questions and free-response items, the latter requiring pupils to write their own answers. There were 104 multiple choice questions for science. The difference between the pupils' performance on the multiple-choice questions and the free response Items was marked. The fact that less than 20% of the pupils answered most free response items correctly means that most South African pupils, in addition to lacking the basic science knowledge, do not have adequate communication skills in the language of the test to articulate their scientific answers and findings in writing.

[3] On a scale of 800 points

From the exemplar items analysed for the report, pupils seem to do better in the items that relate to the basic knowledge about the earth's features and human biology and those that they could relate to everyday experiences. There was even an item considered internationally difficult which the South African pupils did particularly well on compared to other countries although the percentage of pupils getting it correct was still low. Clearly, pupils have trouble with the interpretation of tables and graphic representations. As for mathematics, they struggle with complex questions that need more than one step. They experienced difficulty doing seemingly straightforward calculations. The performance in the items where they had to write their own answers was very poor and much lower than that for the multiple choice questions. It appears that for multiple choice questions many pupils are dependent on guessing the correct option and thereby achieve a higher score than by writing a correct answer to the open ended questions.

7. TREND DATA FOR MATHEMATICS AND SCIENCE FROM 1995 to 1998

As mentioned earlier, a number of items from the 1995 mathematics and science tests were included in the 1999 instruments in order to analyse any trends that might emerge. In this section, the results of this analysis are described.

7.1 Mathematics trends

There are 26 countries in TIMSS-R that also participated in the original TIMSS study, including South Africa. Overall, the international average achievement in mathematics did not change, as there is only a small increase by 2 scale points (from 519 in 1995 to 521 in 1999 across the 26 countries). As can be seen in Appendix C, South Africa's overall score decreased by 3 scale points, which was not statistically significant. In other words, there is no real difference in performance between the pupils in 1999 and those in 1995.

The difference in achievement between 1995 and 1999 for the **top 10%** was minimal and not statistically significant for any country including South Africa. Less than 0.5% of pupils in South Africa reached the top 10% in both 1995 and 1999; this is reported in Appendix C as 0% in both 1995 and 1999 since all figures were rounded off. South Africa was the only country where this happened in both years.

Internationally, there were no significant differences in achievement for mathematics for either girls or boys between 1995 and 1999. On average, girls performed 3 points better than in 1995 and boys achieved 2 points more. In South Africa there was an increase in the score for girls (from 264 in 1995 to 267 in 1999). There was a decrease in the score for boys, who on average scored 10 points less in 1999 (from 293 in 1995 to 283 in 1999). Neither of these results is statistically significant.

In terms of gender differences between girls and boys, there were significant differences in some countries in 1999, as in 1995. An important finding, however, is that fewer countries had these

differences (3 compared to 6) in 1999. In 1995, the Czech Republic, Iran, Japan, Korea, the Netherlands and Israel all had significant differences in achievement that favoured the boys. In 1999, only three countries still have these significant differences favouring boys; the gap has decreased in others. There were no significant differences found in 1995 or in 1999 for South Africa pupils. Although in 1995 there was a 29-point difference between girls and boys, this gap has narrowed to a 16 point difference in 1999.

The trend data reveal very few changes among the content areas in mathematics, as changes on this level are difficult to effect and take a number of years to show themselves. It is expected that TIMSS 2003 will be able to show more differences in achievement on this level

Overall differences in the percent correct on country level were found for 5 countries, 3 of which were positive increases in achievement. The only significant difference in achievement (between 1995 and 1999) internationally in specific content areas was found in data representation, analysis and probability. The average percent correct of South African pupils decreased by 2% for fractions and number sense, measurement and data representation, analysis and probability, and 1% for geometry and algebra, none of which was significant.

7.2 Science trends

The international average achievement in science increased by only 3 scale points from 518 in 1995 to 521 in 1999 (see Appendix D) and is not statistically significant. Only four countries recorded a positive significant difference, and one had a significantly negative trend. South Africa's overall score decreased by 20 scale points, which was not statistically significant. This means that although the difference seems comparatively large, there is not enough evidence to conclude that there was a real difference in performance between the pupils in 1999 and those in 1995.

The difference in achievement between 1995 and 1999 for the **top 10% of the pupils participating was not statistically significant for any country including South Africa. Less than 0.5% of pupils in** South Africa reached this benchmark in 1999 (and therefore accordingly reported internationally as 0%) compared to 1% in 1995. It was the only country participating in both studies where less than 1% was recorded in 1999.

Internationally, there were significant differences in achievement between girls and boys in the two studies. On average, girls performed 6 points better than in 1995, which was statistically significant, while boys achieved 3 points more, which was not. Four countries were found to have improved significantly in achievement and one country had declined. In South Africa there were negative tendencies for both girls (from 243 in 1995 to 234 in 1999) and boys (from 283 in 1995 to 253 in 1999), although neither of these results is statistically significant.

There is also a significant difference internationally between genders in 1999 (512 points for girls compared to 531 for boys) as

in 1995 (girls, 506 points compared to boys, 527). In 1995, most of the countries (19 out of 26), including South Africa, showed a significant difference favouring the boys. Fewer countries have a significant difference in 1999 (13 out of 26), but all favoured boys. While there was a significant difference found in 1995 (243 points for girls compared to 283 points for boys), no such significant difference was found in 1999 (234 for girls and 253 for boys) for South Africa pupils, although there was a 19 point difference compared to a 40 point difference in 1995.

7.3 Trends in content areas for science

Like for mathematics, the trend data reveal very few changes among the content areas. It is expected that TIMSS 2003 will be able to show more differences in achievement on this level.

Overall differences in the percent correct at country level were found for Canada, Latvia and Thailand, the first two of which were positive increases in achievement. The only significant difference in achievement internationally in specific content areas was found in Life Science. In this content area, three countries had significantly higher percentages in 1999 and two declined. In Earth Science, significantly increased percentages were found in three countries, while a significantly lower percentage was obtained by three others in 1999. In Physics, significant gains were made by three countries, but the Slovak Republic and Thailand both achieved significantly lower percentages in 1999. In Chemistry, two countries improved significantly, while Thailand achieved significant lower percentages correct for this area.

The results of the South African pupils remained the same for Earth Science, while 1% less pupils answered Life Science questions correctly (from 38% to 37%). The percentage dropped by 3% for Physics (from 37% to 34%) and for Chemistry (from 38% to 35%). However, this negative trend across all content areas is not statistically significant.

8. BACKGROUND INFORMATION ON SYSTEM, SCHOOL, CLASS AND PUPIL LEVEL

Much of the background information collected in TIMSS-R provides valuable information by which the results may be interpreted and explained. The key findings from the contextual information are summarised in this section, according to system, school, class and pupil levels.

8.1 System level

1. The mathematics curricula in 73% of the countries had been in place for less than 10 years. Most were undergoing revision at the time of testing.
2. Science curricula were undergoing revision at the time of testing in 68% of the countries.
3. Of TIMSS-R countries, 55% offer general or integrative science and not separate science courses.
4. The specifications for mathematics and science curricular goals were developed at the national level in 92% and 95% of countries respectively.

5. Public examinations assessing achievement in mathematics and science existed in one or more grades in 86% and 95% of countries respectively. The majority of these conducted their examinations at the end of secondary school (mostly Grade 12 but sometimes at a lower grade). This was done for certification purposes and/or to select pupils for higher education, especially for university.
6. Two-thirds of the countries in the study conduct some form of system-wide assessment for mathematics and more than half implement system-wide assessments in science. Approximately half of these tested all the pupils and the other half tested a sample in a target grade.
7. Internationally, a major emphasis was given in mathematics to mastering basic skills (by 28 countries, including South Africa) and even more so to understanding mathematics (by 31 countries, including South Africa).
8. Internationally in most countries, a major emphasis in science was given to knowing basic science facts (28 countries) and to understanding science concepts (31 countries). However, South Africa did not do this and placed a moderate emphasis on these aspects.

8.2 School level

The results given here refer to South Africa unless otherwise specified.

1. Of teachers at South African schools, 68% are at the same school for 5 years or longer.

2. The average class size in Grade 8 is 46 pupils.
3. The largest class found was 95 pupils.
4. Urban schools are larger than rural schools. Average enrolment in urban schools is 1 028 while rural schools had 622 pupils on average.
5. Pupils are required to live in the area by 66% of schools.
6. One-third of schools consider academic performance and interviews with parents as important admittance criteria.
7. Parents are expected to volunteer for school projects, programmes or field trips by 97% of schools.
8. Principals in South African schools spent much less time on instructional leadership and much more on teaching than their international peers.
9. The average number of school days was 195. However, the number of instructional school days reported by the principals varied from 120 to 280, and principals of 15% of pupils reported that there were one or more days of less than four hours at school.
10. The shortest school lesson time reported was 15 minutes.
11. Principals of 45% of pupils reported that instruction was hampered by the shortage of instructional materials and 31% by inadequate space.
12. Grade 8 pupils are missing school very regularly. Principals of 69% of pupils reported that Grade 8 pupils are absent from school daily and/or weekly and 75% report that pupils arrive late for school.
13. Principals of 20% of schools report serious drug problems at Grade 8 level.

14. Vandalism of school property is a serious problem reported by principals of 34% of pupils.

8.3 Teachers and instruction

Caution is advised here when interpreting the results as they are not representative of teachers in South Africa since the schools and pupils rather than the teachers were sampled randomly; All the teachers of the pupils being tested had to complete questionnaires. Nonetheless, although the results cannot be generalised it is believed that they provide a good indication of the situation in schools and classrooms. The information in this section pertains to South African teachers unless otherwise specified.

1. Only 39% of mathematics teachers and 47% of science teachers are female.
2. Generally, pupils who have mathematics and science teachers older than 40 years achieve better scores in mathematics and science.
3. South Africa does not retain its mathematics and science teachers. Only 16% of South African mathematics teachers and 12% of science teachers are over 40 years of age.
4. 27% of pupils were taught mathematics by teachers with no formal qualifications in mathematics.
5. 38% of pupils were taught science by teachers with no formal qualifications in science.
6. Approximately half the mathematics teachers do not feel confident to teach mathematics and about half of the science

teachers do not feel prepared to teach science to Grade 8 pupils.

7. The average class size for mathematics was 50 pupils and for science 49 pupils.
8. South African teachers spend more time on administrative tasks than teachers in other countries.
9. South African mathematics teachers placed a higher emphasis on using a calculator than teachers internationally. Pupils of South African teachers who placed a low emphasis on calculators in class attained higher scores in mathematics.

8.4 Pupils and home background

1. The South African pupils were the oldest in TIMSS-R. The average age of South African Grade 8 pupils is 15.5, while the international average is 14.4 years. Ages ranged from 9 to 28 years.
2. Almost half of the pupils (40%) live without their father at home.
3. Only 26% of pupils spoke the language of the test as their first language, and these did better in both mathematics and science. More than 70% of pupils from South Africa, Indonesia, Morocco, the Philippines and Singapore did not always speak the language of the test at home.
4. Pupils whose parents had higher education achieved higher scores for both mathematics and science.
5. Pupils with more books and educational aids in the home did better in mathematics and science.
6. South African pupils have a very poor self-concept in

mathematics and science compared to pupils internationally. They find both subjects difficult, believe that they are not talented in either subject, and that it is not their strong point.

7. Despite their poor self-concept, South African pupils have a more positive attitude toward mathematics than towards science and generally more positive towards both these subjects than pupils internationally.
8. 55% of South African pupils intend to finish university, which is higher than the international average.

9. IMPLICATIONS FOR POLICY AND PRACTICE

9.1 Introduction

A project such as TIMSS may serve both monitoring and evaluation functions for policy makers. On the one hand this cycle of mathematics and science studies that the IEA has embarked on through TIMSS – the first being 1994/1995, the present study in 1998/1999, and in the future in 2002/2003 – means that there is a systematic and regular collection of important data on national and international levels. On the other hand, should policy makers decide so, it may also serve an evaluation function in that this systemic collection of data and its interpretation may lead to action based on a judgement of the value of the data collected.

Clearly challenges for education in this country are continuing to mount and much has to be done in the coming years to improve the quality of South African education, in particular mathematics and science education. With this in mind, the author has selected a number of issues where the data suggest action may be appropriate and where it seems feasible.

9.2 *Teacher preparation and retention*

On the whole, about half of the teachers reported feeling ill prepared to teach the content of either the mathematics or the science curriculum. On inspection of the qualifications and experience of these teachers, this is not surprising. There appear to be few teachers with significant experience and a relatively small percentage have university level qualifications. Those that have qualified through the three year diploma from colleges of education probably did not go beyond repeating the subject they did at school in Grades 10-12. The lack of adequate preparation in terms of content knowledge in particular have left these teachers feeling poorly prepared to teach their pupils; the teachers are constrained by this in the classroom. Since resources are lacking in many schools and the teacher is often the pupils' only resource to learning, it is not surprising when the end result is so poor.

9.3 *Curriculum issues*

The South African curricula for mathematics and science are undergoing development as part of the revision of Curriculum 2005. However, an analysis of the interim curricula for these subjects revealed several similarities with curricula internationally. One of the exceptions was the lack of major emphasis in science on

knowing basic science facts and understanding science concepts. While most countries placed a major emphasis on this in the curricula documents, South Africa did not. Given South African pupils' apparent lack of basic science knowledge and understanding of science concepts, it is possible that this may also be a contributing factor to South African pupils' underperformance in science.

9.4 *Home background and language*

Most of the pupils participating in TIMSS-R came from a low socio-economic background with few books in the home and few, if any, educational aids. These factors are known to be related to achievement. The parental educational levels of these pupils were generally fairly low. Pupils lived with several people in the home, although only 60% have a father living in the home. Although schools cannot change these factors, it is important that steps are taken to ensure that pupils from these backgrounds are compelled to attend school, being the only opportunity in many cases to provide for the future.

The majority of pupils tested in South Africa were not fluent in the languages of testing, be it English or Afrikaans, and struggled to communicate. The possible lack of fluency on the part of the teachers would exacerbate this situation further and disadvantage the pupils even more. Although other countries had similar problems of pupils having to learn in languages other than the one they spoke at home – for instance Malaysia, Indonesia, Singapore and the Philippines – their pupils did not appear to have been disadvantaged by this. In at least two cases (Malaysia and Indonesia) there is one common language in which all pupils have to receive their instruction. Clearly the language issue contributes to the poor subject knowledge of both teacher and pupil in South Africa and if there is to be a commitment to improving the levels of pupils' performance in these core subjects in the future then solving the language issue is a critical part of this solution.

9.5 *Instructional time*

The time allocated to mathematics and science at schools in South Africa appears to be generally in line with schools internationally. However, the number of school days varies tremendously between schools and it would seem that some schools are cutting short the school days and are still far from the seven-hour compulsory school day recently introduced. Furthermore, there seems to be a serious problem of absenteeism, which appears to be much more serious in South Africa than in many countries. Therefore, although adequate time is officially allocated, the time that is actually spent in instruction on mathematics and science is vastly reduced in some cases.

9.6 *Pupils' attitudes towards mathematics and science*

On the whole, South African pupils were positive towards both subjects, more so towards mathematics than science. The high rate of absenteeism reported among this age group indicates that the problem lies more with pupils being motivated to attend school. Pupils did not appear confident in their ability in either subject and perhaps given their results this seems realistic. Pupils find the

subjects difficult, but the context within which they learn these subjects is challenging. The lack of qualified, confident teachers and lack of equipment and facilities will engender this lack of self-efficacy towards these subjects. There is an urgent need for programmes to be put in place which will nurture the apparent positive attitudes towards the subject, to build up pupils' fundamental knowledge and understanding of the basic concepts in both subjects as well as that of the teachers.

9.7 *Resources*

About half of the schools indicated that they felt that instruction in mathematics and science was seriously hampered by a shortage of materials, equipment and facilities. In particular, there is still a shortage of calculators at many schools, which are both prescribed in the curriculum but are also an essential part of pupils' learning. It is apparent that the legacy of the past is still very much present in this regard.

9.8 *Homework*

Pupils seem to be given more homework than many of their international peers. However, it also appears necessary that more homework be given. More homework was not linked to greater achievement in South Africa, but was in other countries. This is perhaps due to below average pupils requiring more time to complete their assignments than more able pupils. In general, teachers checked the homework (although about 25% never did), but spent far more time doing so than teachers internationally. This would also cut into time perhaps allocated to new topics and therefore result in teachers not finishing the syllabus, a fairly common occurrence in South African schools.

10. CONCLUSION

This report is very descriptive and factual in nature. However, some attempt has been made to contextualise these results. At this stage much of the interpretation has been left to the reader. However, this is only the start of the analysis of the data collected in TIMSS-R. Still to come are the explanations for the performance of South African pupils, and this can only be achieved through the secondary analysis planned for 2001, which will be published in two reports. The planned research using multi-level analysis and other exploratory techniques will also investigate the link between the issue of exposure to language and the related achievement in mathematics and science. It is hoped that this research will further illuminate factors that promote effective learning.

The TIMSS-R results will no doubt be disappointing to those working hard to change the situation in schools on a systemic level. To those working at school level, they are not surprising. However, the performance of South African pupils' has remained constant despite an increase in throughput of pupils. Nonetheless, there is a lack of comparability of South African pupils' results with those of their peers in other developing countries, a number of which participated in 1998/1999.

For the first time in South Africa, there is a comprehensive data-set including data on school, class and pupil level which has been

successfully collected for the first time in South Africa and provides true baseline data for further analysis. The advantages of such a quality database will be verified in the next collection of data in 2002/2003 when a full data collection on three populations of pupils will again be conducted internationally.

It remains to be seen whether the picture that emerges when comparing the South African data from 1995 and 1998 continues or changes in 2002/2003. On a pragmatic note, it may be too much to hope to detect definite and/or significant trends over such a short period. However, this in itself potentially makes the 2002/2003 study more important, as it will be more likely to enable the measurement of any developments between 1995 and 2002.[4] This type of monitoring of an external and independent comparative study provides a valuable assessment of the true progress of the education system and its initiatives.

Now that access to education and the right to learn have been established for the majority in the country, it is time to set key priorities for the country's future. If South Africa wants to succeed in a rapidly changing and competitive technological world, it will need to develop and protect its capacity to produce well-qualified human resources. In order to improve the lack of change detected by TIMSS-R from developing further, resources have to be put into a variety of well-designed, planned and effective programmes promoting and implementing mathematics and science. Greater

[4] Southern hemisphere countries will collect their data in 2002 and the Northern hemisphere countries in 2003.

collaboration within and between government and the private sector will be required to optimise energies and resources. This is urgently needed to increase the number of pupils with the adequate and well-founded knowledge and skills in these subjects to create a critical mass of matriculants able to move into higher education, business and industry in the short, medium and long term.

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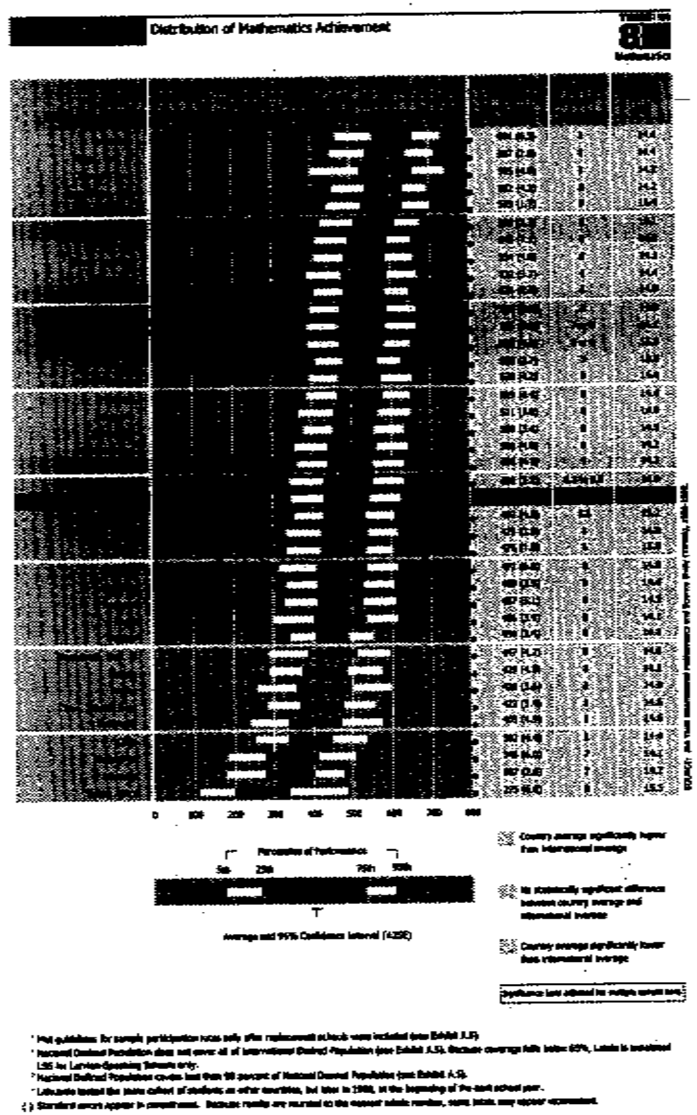
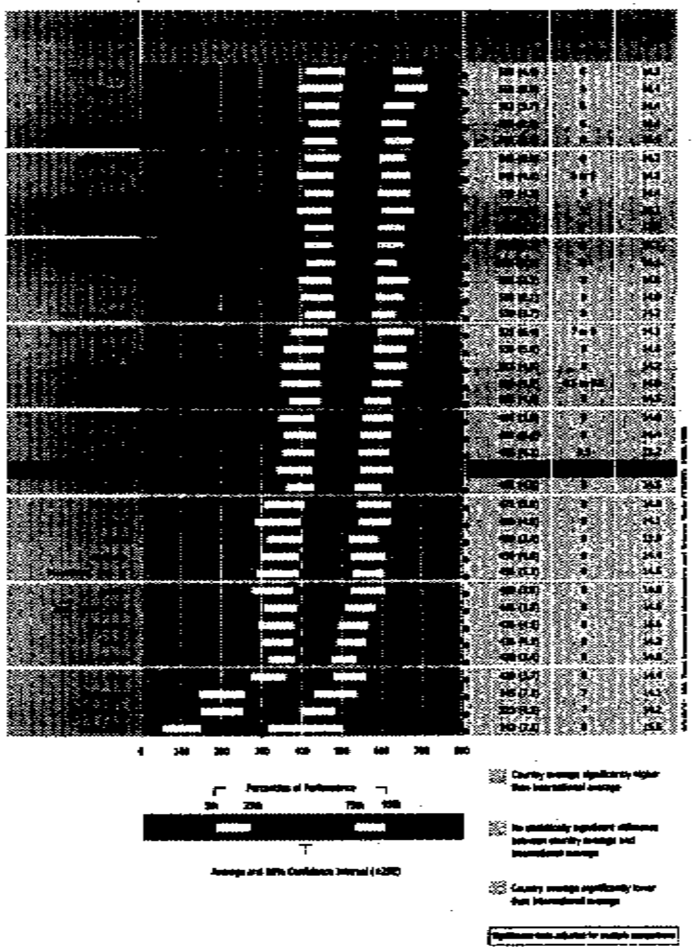
Appendix A



Appendix B

Distribution of Science Achievement



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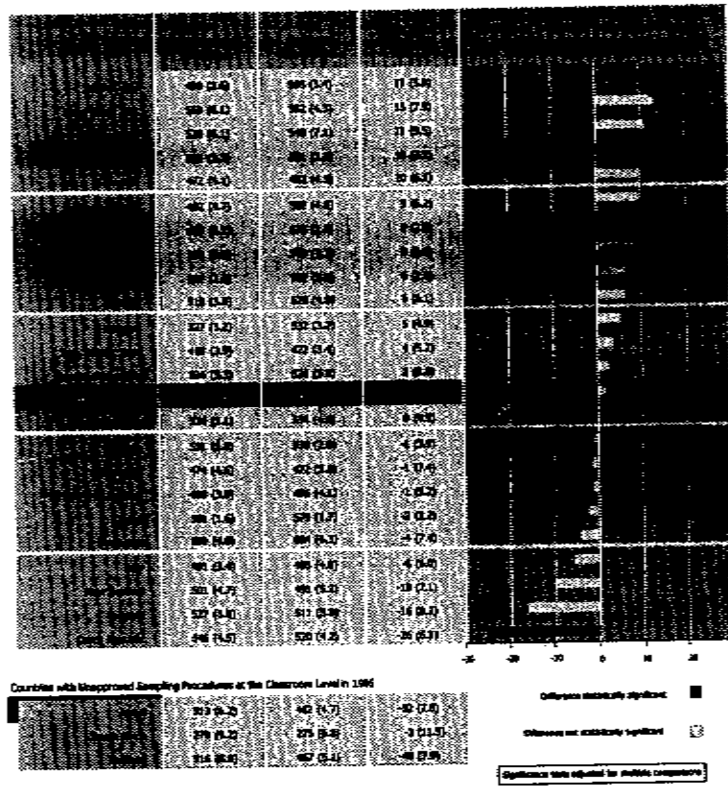
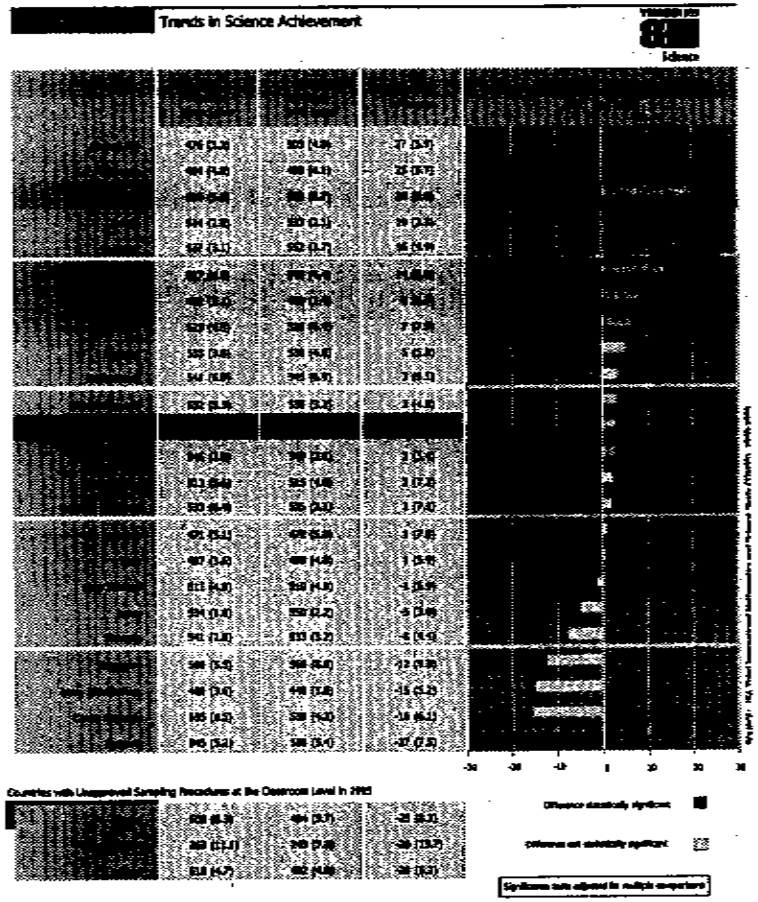
Appendix C

Trends in Mathematics Achievement



[1] International average is for countries that participated and met sampling guidelines in both 1995 and 1999.
Trend notes: Because coverage fell below 65% in 1995 and 1999, Latvia is annotated LSS for Latvian-Speaking Schools only. Lithuania tested later in 1999 than in 1995, at the beginning of the next school year. In 1995, Italy and Israel were unable to cover their International Desired Population; 1999 data are based on their comparable populations.
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Appendix D



† International average is for countries that participated and met sampling guidelines in both 1995 and 1999.
Trend notes: Because coverage fell below 65% in 1995 and 1999, Latvia is annotated LSS for Latvian-Speaking Schools only. Lithuania tested later in 1999 than in 1995, at the beginning of the next school year. In 1995, Italy and Israel were unable to cover their International Desired Population; 1999 data are based on their comparable populations.
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