BOTSWANA REPORT

BOTSWANA EXAMINATIONS COUNCIL

TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS) 2015

TIMSS 2015

TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS) 2015 REPORT

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TABLE OF CONTENTS

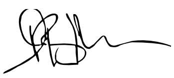
FOREWORD

Contained in this report are the findings of the 2015 cycle of the Trends in International Mathematics and Science Study (TIMSS). The 2015 cycle was the fourth in which Botswana participated since 2003. Unlike in previous cycles, Botswana participated only in the TIMSS. Botswana did not take part in the Progress in International Reading and Literacy Study (PIRLS), which runs concurrently with TIMSS. The target for the 2015 cycle were learners who at the time of the study had completed eight years of formal schooling.

Collectively, the four studies have generated significant amount of information on the country, which can be manipulated to inform quality efforts in education, and particularly in mathematics and science. The information accumulated did not only provide valuable insight into students' academic performance, but also valuables lessons on best practices in curriculum delivery, modern pedagogical and assessment practices, as well as ideal learning environments with respect to each of the participating countries. The studies also yielded indices that could be used to monitor the country's global competiveness in learning achievements in mathematics and science.

Regrettably for a number of reasons including budgetary constraints, Botswana is not participating in current TIMSS. The current cycle (TIMSS 2019) or eTIMSS as it is commonly referred to, is unique in the sense that learners in the participating countries write the tests online. A major expectation of the study is the promotion of 21st century skills, non-participation by Botswana is thus an unfortunate development because the country is on the drive to produce a 21st century learner. However, all is not lost, as this provides opportunity for Botswana to implement policy recommendations from previous and current cycles. The huge data accumulated over the years is also available to researchers, policy makers and planners and other interested parties to analyse it further and come up with further recommendations that may lead to further improvements in the education sector.

The TIMSS 2015 study provides insightful and invaluable information on students' achievement in mathematics and science, as well as factors that impacts teaching and learning in these areas. It is a must read for educational policy makers, teachers, planners and all other stakeholders interested in improvements in the education sector and the transformation of Botswana into a knowledge-based society.



Brian Mokopakgosi
Chief Executive Officer
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This study would not have been completed without the collaborative effort from several education stakeholders. Our gratitude for the successful completion of the TIMSS 2015 study goes mainly to the Botswana Examinations Council (BEC) and by extension, the Ministry of Basic Education (MoBE) for supporting, financially, the National Research Coordinator in all National Research Coordinators (NRCs) meetings and training workshops hosted in various countries. Various offices of the IEA such as The International Study Centre in Boston, Statistics Canada and the Data Processing Centre in Hamburg are acknowledged for tirelessly guiding the BEC through the study processes.

Sincere gratitude also goes to the Regional Education Offices that permitted BEC to conduct the study in schools in their regions. Our gratitude extends to the School Administrators who due to their appreciation of the significance of the study, and despite their tight personal schedules, still found time to support BEC in conducting the study. The successful conduct of the study was hinged on the cooperation and preparations made by the School Coordinators, for both Field Test and Main Survey. For that, BEC salutes their commitment. BEC would also like to thank all the teachers who participated in the completion of the questionnaires which enabled us to have an insight into the teachers' factors that are linked to students' performance. Parents who permitted their children to take the tests are as well highly appreciation, the Parents did not only permit their children to participate in the study, they also participated by completing the parents questionnaires.
Lastly, we thank all the Form 2 students who participated in this very important study. They were true ambassadors of this country; they represented other students and their country well.

Data collection engaged a number of people from all sectors of education. Some were instrument administrators, some acting as National Quality Control Monitors, while others acted as International Quality Control Monitors. There are so many to mention by name, all of them provided an important service. Thank you very much. We are also indebted to the teachers who helped in the scoring of both the pilot and the main study instruments. At school level, School Coordinators handled all matters connected with the project and did it exceptionally well. Finally, a great deal of acknowledgement also goes to all staff members of Botswana Examinations Council for the various roles each played in the project.

EXECUTIVE SUMMARY

The meaning and purpose of TIMSS

The 2015 cycle is the fourth cycle of Trends in International Mathematics and Science Study (TIMSS) in which Botswana has participated. TIMSS is administered by the International Association for the Evaluation of Educational Achievement (IEA). The Association is a network of countries around the globe who are interested in the extent to which their learners have mastered what they are taught in Mathematics and Science and how their learning achievements compare with those of learners at the same level in other countries. Forty-five countries, Botswana included, and 14 benchmarking participants administered the eighth grade assessment in the TIMSS 2015 cycle.

The main objective of TIMSS is to assess levels of Mathematics and Science aptitude of learners around the world. The ultimate aim is to generate and make available a rich source of information to policy makers, education managers, curriculum developers, teacher trainers, teachers, assessment bodies, researchers and all stakeholders on the learning outcomes of Mathematics and Science. It also assesses how the learning environment of the learners relate to their learning achievement.

Another important objective of TIMSS is to compare the achievement of learners in the participating countries in Mathematics and Science and to assess the extent to which learners' respective learning environments impact their learning country by country.

Why Botswana participated in the TIMSS

The rationale for Botswana's participation in TIMSS has not changed since 2003. There is a national goal to be competitive and to use Mathematics and Science as vehicles for economic growth. Botswana remains committed to improving qualitative aspect of the educational attainment to enhance the quantitative success that was realised by promoting access to schooling. Both the Revised National Policy on Education (RNPE) and Vision 2036 advocate for the improvement in the quality of learning. Pursuant to recommendation 17b, Revised National Policy on Education (RNPE), 1994, p. 17), TIMSS is regarded as one programmes that can used for monitoring performance of education. Information obtained from TIMSS is used for informing curricula reviews as well as planning and implementing educational initiatives. TIMSS further provides an opportunity for Botswana to compare her learners with counterparts elsewhere in the World, this further provides an opportunity for benchmarking best practices from around the world, hence a possible improvement in the performance of education.

How the study was conducted

Each cycle of TIMSS starts with development of assessment framework. For the 2015 cycle, sometime was devoted to analysing the commonality between the TIMSS assessment frameworks and the Botswana Form I curriculum. To qualify for participation, a country has to have a curriculum that overlaps with the TIMSS Frameworks by at least 70%. The frameworks are a blend of curricula from among participating countries and no country will have a curriculum that fits the TIMSS framework perfectly. After developing the frameworks, test items were constructed to cover the Mathematics and Science contents defined by the frameworks. Questionnaire items were constructed to elicit background information from students, teachers, school heads and parents.

In the case of Botswana, 25 schools participated in the pilot test. Two classes were sampled from each school to participate in the pilot study. For the main survey, 150 schools participated and, from each school, one class was sampled to complete the instruments. Thus, 150 school heads responded to the research instruments. A school coordinator was appointed by each sampled school, and these coordinators were trained on the study processes and their roles. The names of the students in the sampled classes were obtained and captured into the study database.

For an international study like TIMSS, it is essential that the study processes and procedures are highly standardised. Therefore, Botswana teachers were trained on how to administer both the pilot and the final data collection instruments. Teachers were used as coders and they were also trained in the procedure TIMSS uses for scoring the work of learners. Botswana coders were mostly teachers from the Junior Secondary Schools.

A great deal of effort was expended on data capturing which was done manually. The captured data was transmitted to the TIMSS's Data Processing and Research Centre (DPC) for cleaning and verification. After data cleaning, scoring and scaling by DPC, countries were then allowed to carry out their own analysis and write reports. IEA uses International Database Analyser (IDB Analyser), which the participating countries also use for data analysis.

Major findings

Performance of Botswana students

TIMSS tests are scored on a scale of 0 – 1000 points, with 500 being the centre point of the scale. On this scale, Botswana students scored 390 and 391 out of 1000 in Mathematics and Science respectively. Both scores were below the TIMSS scale centre point of 500. That was so, despite the fact that Botswana participated with learners from a higher grade. Out of the 39 countries that participated, Botswana was ranked third from the bottom in Mathematics and fifth from the bottom in Science.

The observed performance by Botswana learners averaged of 23% and 29% correct in Mathematics and Science tests respectively. The international averages were 42% in Mathematics and 44% in Science. Botswana learners went on to record about the same performance on items identified to be coming directly from Botswana curriculum. Thus, Botswana students were not only unable to achieve high scores in the TIMSS items but also in the Botswana TIMSS test – which constituted of items coming from her own curricula. This indeed proved that the TIMSS assessment framework, and subsequently the TIMSS test did not favour any particular country. Botswana girls continue to perform better than their male counterparts, a common phenomenon even in other participating countries, however it is important to note that Botswana registered the second highest significant differences between girls and boys performance in Mathematics.

The ten educational regions of Botswana were compared on performance; South East performed the highest in both subjects, followed by the North East region. These were the only two regions with a mean performance above 400. Kgalagadi region performed the least in both subjects.

Four regions, namely South East, North East, Kgatleng and Chobe, scored above the country mean in both Mathematics and Science. On the other hand, Kgalagadi, Southern and Kweneng regions scored below the country mean, hence contributing significantly in the country's low mean score. The poor performance could be attributed in part to unsatisfactory provision of resources such as physical infrastructure, equipment, machinery, teacher capacitation, and time on task.

Students from private schools performed above the TIMSS scale centre point of 500, and far much higher than students in public schools in both Mathematics and Science. They outperformed public school learners by at least 100 points.

In Mathematics, only 32% of the multiple choice items were accessible to Botswana students compared to 74% internationally while in Science, 54% of the multiple choice items were accessible to Botswana students compared to 86% internationally. The highest percentage of students who omitted a single Mathematics multiple choice item was 15% while for structured items it was 24%. In Science, up to 35% of the students omitted multiple choice items and up to 25% omitted structured items. Items in which students did not perform well were identified to be coming from the following content domains and topics:

Mathematics:

I. *Number*: fractions, decimals and integers; ratio, proportion and percent and whole numbers.
II. *Algebra*: *equations* and inequalities; expressions and operations, and relationships and *functions.*
III. *Geometry*: *geometric* measurement, geometric shapes, and location and movement.
IV. *Data and Chance: chance*, *characteristics* of data sets; and data interpretation.

Science:

I. *Biology*: composition of matter, cells and their functions, characteristics and life processes of organisms, diversity, adaptation, and natural selection, ecosystems; life cycles, reproduction, heredity, and human health
II. *Physics*: light and sound, electricity and magnetism, energy transformation and transfer, forces and motion, physical states and changes in matter
III. *Earth Science:* earth processes, cycles and history, earth structures and physical features, earth in the solar system and the universe, earth's resources, their uses and conservation.
IV. *Chemistry:* properties of matter, chemical change, physical states and changes in matter.

Some contextual factors were associated with students' achievement more than others. The majority of these factors were students-related and they accounted for 57.5% of the variability in achievement. However, some teacher specific factors (5.1%), school specific factors (5.1%), and parent specific factors (2.4%) were also found to be associated with students' performance. The dominance of students' related factors suggested that for any meaningful improvement in students' achievement to be realised, students' concerns should be given primary consideration and any intervention devised to address such should be done in consultation with the students. Specific students' factors revolved around learners' attitude and perception towards learning. Although the factors were common among the regions, they varied in intensity and ranking.
Given the foregoing, it is recommended that:

1. Teacher training institutions should give more emphasis to the identified difficult topics in Mathematics and Science. Likewise, for the in-service teachers, more

workshops should be conducted to impart teachers with the necessary knowledge and skills on the listed topics.

2. Given that schools are less safe and orderly than before, and that indiscipline and bullying are on the rise, it is imperative therefore that the system strengthens the schools' support system by hiring more and diverse professionals such as Social Workers, Counsellors, and Psychologists who are more equipped to deal with immoralities emerging in modern schools, such as bullying.

3. The schools should establish a culture of cooperation and collaboration between the various stakeholders such as parents and the community for active participation to enhance teaching and learning. Likewise, there should be interconnectedness within the school as a micro community with strong school management to lead and guide.

4. Educational outcomes can improve when students do what they like. This can be achieved by developing interventions which encourage them to engage in meaningful learning, in collaboration with them, such as developing open curriculum which offers students a variety of subjects or a variety of learning pathways to choose from.

5. The use of digital devices in learning should be highly encouraged as it had a positive relationship with students' achievement. As a consequence, all schools should be equipped with digital devices connected to the internet to provide a diverse source of information to facilitate learning. However, the use of digital devices should be monitored and controlled so that they do not end up being abused.

6. Education is a communal endeavor hence all stakeholders should be actively involved in imparting education to learners. The system should therefore devise means to encourage parents, the community, civil societies, NGO's and society at large to participate in educating the child. When parents are well informed of their role in children's school work, they contribute meaningfully in the school's decision making process with the wash back in students' performance.

7. There is need for the Ministry of Basic Education to conduct an audit of school resources to inform subsequent resource allocation. Regions performing poorly should be allocated more resources than others. Furthermore, more support should be directed towards such regions.

CHAPTER ONE: INTRODUCTION

What is Trends in International Mathematics and Science Study?

This is the fourth cycle of TIMSS that Botswana is participating in to assess its educational quality in Mathematics and Science. TIMSS also allows for comparison of educational qualities of participating countries. For this reason, Botswana joined the International Association for the Evaluation of Educational Achievement (IEA), founded in 1959 for the purpose of conducting comparative research studies on educational policies, practices and outcomes, one of which is the Trends in International Mathematics and Science Study (TIMSS).

TIMSS is an international assessment of Mathematics and Science at the fourth grade, eighth grade and A-level that is conducted every four years since 1995. TIMSS grade 8 targets students who have had 8 years of schooling from the first year of International Standard Classification of Education (ISCED) level 1. Eighth graders are all students enrolled in the grade that represents eight years of schooling from the first year of ISCED Level 1, provided the mean age at the time of testing is at least 13.5 years. ISCED Level 1 has six years of schooling and normally corresponds to primary education or the first stage of basic education (UNESO Institute of Statistics, 2012; ISCED, 2012). Thus, TIMSS is a project aimed at assessing what pupils at various stages of learning Mathematics and Science know and are able to do.

TIMSS administers test instruments, and background questionnaires for teachers, students, schools and parents. Southern Hemisphere countries collected data in October/December 2014 while the Northern Hemisphere countries collected their data in May 2015.

The Aims of TIMSS

The goal of TIMSS is to help countries make informed decisions about how to improve teaching and learning in Mathematics and Science. Thus the following constitute the major objectives of the TIMSS project:

I. To assess the level of learning in Mathematics and Science
II. To identify factors that impact on teaching and learning
III. To detect trends in the learning achievement as well as the education system in general

IV. To compare achievement in relation to teaching and learning conditions among participating countries
V. To provide a rich source of information to policy makers and other stakeholders

The study findings provide policy makers, education managers, curriculum developers, teacher trainers, assessment bodies, researchers and all stakeholders with a rich source of information that can be used for the advancement of Science and Mathematics education. Information generated through TIMSS is intended to be used by educators to plan and execute activities that lead to improved learning of Mathematics and Science. Instead of one country believing that the standard of its Mathematics and Science education is high, an opportunity is provided so that each country can compare its standards with those of other countries. Basing the assessment on a common framework enables each country to diagnose the strengths and weaknesses in its Mathematics and Science curricula. These comparisons are very pertinent in a world that is quickly shrinking into a tiny village through digital and technological advances.

Contextual Background to the Study

The resolve of the Ministry of Education to use assessment as a means of monitoring and uplifting the quality of education can best be understood by taking a look at where the country intends to go. Indeed Vision 2036 has become the cornerstone of Botswana's development. With regards education, it states thus: ''Botswana society will be knowledgeable with relevant quality education that is outcome-based, with an emphasis on technical and vocational skills as well as academic competencies''. It goes on to say that this will be achieved partly by teaching Mathematics and Technology right from primary to tertiary level.

The Education and Training Sector Strategic Plan (ETSSP) outlines eleven thematic areas, one of which is a shift from content-based curriculum to outcome-based curriculum, accompanied by appropriate assessment systems to facilitate the development of technology among the students. It is hoped that the introduction of this quality and relevant education will go a long way to produce high quality labour force characterised by creativity and innovativeness to counter the country's low global ratings on labour productivity.

Given what education has to achieve, the need for monitoring becomes an imperative action. It is no longer just a matter of participating in TIMSS for the fulfilment of the policy of continuous monitoring (REC.17b of the RNPE, 1994, p. 17), but indeed a check to see if the thrusts that had been put into the process of education and the interventions emanating from previous TIMSS reports' recommendations had an impact. In other words, the 2015 cycle was to check if Botswana was becoming more and more competitive in accordance with the aspirations expressed in various education policy documents.

Botswana opted to participate in TIMSS 2015 eighth grade only (using Form Two's) due to limited resources. It must be noted that TIMSS targets grade four and grade eight. The reason to participate at Form Two level was because the TIMSS 2011 pilot test results indicated that Botswana Form One students (eighth graders) were unable to answer most TIMSS items hence the reliability of the results was wanting.

Conceptual Framework for the Study

The determination of Botswana to utilise education to prepare the country to be progressive and technologically oriented is quite strong. This is reflected in the RNPE (1994, p.21) and operationalized in the goals of the Junior Certificate curriculum:

- the capacity to use computational skills for practical purposes;
- an understanding of scientific concepts and interest in the material world;
- an appreciation of technology and the acquisition of basic skills in handling tools and materials;
- computer literacy – each pupil is to take basic computer awareness course (Recommendation 32);
- critical thinking, problem-solving ability, individual initiative and interpersonal skills

Having participated in TIMSS 2003, 2007 and 2011, there was a keen interest in finding out if the performance of Botswana pupils had improved. Not only was there interest in finding out if performance had improved, but also the standing of the country in comparison to the other participating countries. The fact that the country set itself high standards by comparing itself with the best countries in the world was a driving force for moving forward with TIMSS 2015.

Educational Structure of Botswana

Botswana operates a 7:3:2:4 system of education. Primary education takes seven years while Junior Secondary education lasts for three years. Learners selected to go into senior secondary education take two years. In the same way, university education takes four years for most courses/programmes.

Pupils take the Primary School Leaving Examination (PSLE) at the end of primary education. The PSLE results are used to provide diagnostic information intended to be used to improve the quality of teaching and learning. Virtually every pupil taking the PSLE proceeds to Junior Secondary, after which they sit the Junior Certificate Examination (JCE). The JCE is a selective examination for those proceeding to senior secondary level. The primary and junior secondary education forms the ten-year Basic Education and the intention is for every child to complete the basic education programme. After two years of Senior Secondary education, learners take the Botswana General Certificate of Secondary Education (BGCSE) examination, the results of which are used for selection into tertiary institutions.

CHAPTER TWO: THE PROCESS OF THE STUDY

TIMSS Working Structures in Botswana

TIMSS is a large scale exercise that requires the involvement of people of diverse professional background. Teachers, Examination Officers, Mathematics and Science officers from the Ministry of Education and Skills Development (MOESD) were involved in the study. Such Professionals constituted the Working Team which had the mandate of scrutinising the TIMSS 2015 draft assessment frameworks.

The developed instrument must be administered. This made it necessary to identify and train staff for the administration of the instrument. During its administration, it was necessary to check that the manual was adhered to. This was done by quality control monitors, who were recruited and trained thoroughly on their role. The International Quality Control Monitors were engaged by IEA while Botswana engaged National Quality Control Monitors. The responses of the pupils on the tests were coded by trained teachers. The curriculum questionnaire was also completed with information obtained from this group of trained teachers.

The Core research team led by the TIMSS National Research Coordinator (NRC) carried out day-to-day operations of the project. The National Research Coordinator was the link with the IEA structures. The participating school appointed a School Coordinator to handle most of the study activities at the school level, who were also trained on their project roles. All communications on the project were subsequently directed to the attention of the School Coordinator.

Population and Sampling

Botswana's target population for the 2015 study was Form Two students. These were students who had nine years of schooling. Botswana and South Africa participated at Grade 9 level (Form Two equivalent) while the rest of the world participated at Grade 8. This was because the pilot results had indicated that the Grade 8 students were scoring too low which introduced a lot of measurement error in the international and respective country results. IEA duly advised that these two countries use students from a higher grade. The names of all Junior Secondary Schools and Private English Medium schools in the country were obtained from the Department of Educational Planning and Research Services (DEPRS) of the Ministry of Education. A form was designed and sent to all these schools to indicate the district and inspectoral region of the school, whether the school is in an urban or rural location, ownership of the school, the number of classes (streams) in Form Two, and the total number of students in Form Two.

This constituted a sampling frame which was subsequently sent to Statistics Canada – an office responsible for handling sampling for IEA. Sampling was a multi-stage, stratified cluster, with the probability of being sampled proportional to the school size. Statistics Canada used software designed for this purpose and sampled 18 schools for piloting and 160 schools for the main data collection. The number of students sampled in the main data collection was 6,192. Two classes were randomly selected in each school for pilot, while only one class was for the main survey. The pilot and main survey sampling was mutually exclusive, that is, schools sampled for piloting were not eligible for sampling for the main survey.

The School Coordinator was requested to list the students in each sampled class. The names of these students were entered into the database, assigned a unique ID using the software supplied by Statistics Canada.

The TIMSS program employs rigorous school and classroom sampling techniques so that achievement in the student population as a whole may be estimated accurately by assessing just a sample of students from a sample of schools. TIMSS employs a two-stage random sample design, with a sample of schools drawn as a first stage and one or more intact classes of students selected from each of the sampled schools as a second stage. Intact classes of students are sampled rather than individuals from across the grade level or of a certain age because TIMSS pays particular attention to students' curricular and instructional experiences, and these typically are organized on a classroom basis. Sampling intact classes also has the operational advantage of less disruption to the school's day-to-day business than individual student sampling.

When sampling has been completed and all data collected, Statistics Canada documented population coverage, school and student participation rates and constructed appropriate sampling weights for use in analysing and reporting the results.

The TIMSS 2015 Field Test

The TIMSS 2015 field test conducted in March 2014 served as a full-scale "dress rehearsal" operationally for the assessment. That is, the data collection and scoring procedures to be employed in the assessment were practiced in the field test. In addition, the field test provided important information about how well each prospective item functioned and provided a basis for selecting items for the assessment.

The field test was conducted in schools. The samples for the field test and the assessment were drawn simultaneously, using the same random sampling procedures. This ensured that field test samples closely approximated assessment samples, and that a school was selected for either the field test or the assessment, but not both.

Table 2.1: *Number of Field Test Items by Content Domain and Item Format*

Subject	Content domain	Number of multiple choice items	Number of constructed response items	Total number of items	Total number of score points	Percentage of score points
Mathematics	Number	19	28	47	51	26%
	Algebra	24	24	48	51	26%
	Geometry	21	25	46	51	26%
	Data and Chance	20	21	41	45	23%
	Total	84	98	182	198	
Science	Biology	31	29	60	72	37%
	Chemistry	15	21	36	38	20%
	Physics	24	19	43	46	24%
	Earth Science	20	13	33	36	19%
	Total	90	82	172	192	

A total of 182 Mathematics and 172 Science items were tried and each item targeted about 200 responses. The number of field test items by cognitive domain and item format are presented in the table 2.2.

Table 2.2: *Total Number of Field Test Items by Cognitive and Item Format*

Subject	Cognitive domain	Number of multiple choice items	Number of constructed response items	Total number of items	Total number of score points	Percentage of score points
Mathematics	Knowing	35	12	47	47	24%
	Applying	32	46	78	83	42%
	Reasoning	17	40	57	68	34%
	Total	84	98	182	198	
Science	Knowing	46	18	64	75	39%
	Applying	32	37	69	74	39%
	Reasoning	12	27	39	43	22%
	Total	90	82	172	192	

Defining the Assessment Frameworks and Item Development

For a country to participate in IEA studies, its syllabus in the school system should match that of the IEA international framework by about 70%. Countries discuss and agree on these international frameworks as the basis for assessing achievement. IEA sends these frameworks to participating countries for discussion and comments at national level. The frameworks are sent with questionnaires eliciting country responses on the content and cognitive dimensions that should be assessed. The 2011 objectives were listed and countries were to indicate against each objective whether it should be retained or dropped for the 2015 assessment. Countries were also asked to suggest new objectives that should be included. These responses were sent to the International Study Centre at Boston College. They then involved expert panels to scrutinise country responses in order to come up with revised frameworks for 2015.

The revised draft was then circulated to countries for their comments before the final version was produced. It is necessary to involve experts and countries at various stages of frameworks development to ensure that what is going to be assessed is appropriate and important. New trends in curricula have to be captured. Test items were based on the international frameworks developed interactively and iteratively by all participating countries. For each curriculum area at each grade, the frameworks were organized around two dimensions: a content dimension specifying the content to be assessed and a cognitive dimension specifying the thinking processes to be assessed.

National Research Coordinators (NRC's) together with Subject matter specialists participated in the development and review of the assessment frameworks; test items; scoring guide; and piloting. The following content and cognitive domains together with their weightings presented in Tables 2.3 and 2.4 were identified to be appropriate for the TIMSS test (Gronmo, Lindquist, Arora & Mullis, 2013; Jones, Wheeler, Centurino, 2013). It should be noted that the TIMSS assessment contained about 200 items for each curriculum area, of which the majority of the items assessed students' Applying and Reasoning skills.

Table 2.3: *Target Percentages of the TIMSS 2015 Mathematics and Science Assessment Devoted to Content Domains at the Eighth grade*

Mathematics	Percentages	Science	Percentages
Number	30%	Biology	35%
Algebra	30%	Chemistry	20%
Geometry	20%	Physics	25%
Data and Chance	20%	Earth Science	20%

Table 2.4: *Target Percentages of the TIMSS 2015 Mathematics and Science Assessment Devoted to Cognitive Domains at the Eighth Grade*

Cognitive Domains	Percentages	
	Science	Mathematics
Knowing	35%	35%
Applying	35%	40%
Reasoning	30%	25%

The percentages reflect the perceived emphasis put on the content and cognitive dimensions in most of the participating countries.

International Benchmarks

The scale of achievement used by TIMSS gives a summary of the performance of students on a test that is designed to measure the achievement of students of wide ability ranges. To make sense of what performance on such a scale means, TIMSS identified four points on the scale and used them as international benchmarks. Items that students at each benchmark are likely to answer correctly are then used to describe the students' knowledge and understanding at that benchmark. This exercise is called scale anchoring. The four benchmarks identified for each subject are low, medium, high and advanced. The brief descriptions of these anchors are presented below with an extended description of each benchmark.

TIMSS 2015 International Benchmarks of Mathematics Achievement

Advanced International Benchmark - 625

Students can organise and draw conclusions from information, make generalisations, and solve non-routine problems. They can solve a variety of ratio, proportion and percent problems. They can apply their knowledge of numeric and algebraic concepts and relationships. Students can express generalisations algebraically and model situations. They can apply their knowledge of geometry in complex problem situations. Students can derive and use data from several sources to solve multi-step problems.

High International Benchmark - 550

Students can apply their understanding and knowledge in a variety of relatively complex situations. They can relate and compute with fractions, decimals, and percentages, operate with negative integers, and solve word problems involving proportions. Students can work with algebraic expressions and linear equations. Students use knowledge of geometric properties to solve problems, including area, volume, and angles. They can interpret data in a variety of graphs and tables and solve simple problems involving probability.

Intermediate International Benchmark - 475

Students can apply basic mathematical knowledge in straightforward situations. They can add and multiply to solve one-step word problems involving whole numbers and decimals. They can work with familiar fractions. They understand simple algebraic relationships. They demonstrate understanding of properties of triangles and basic geometric concepts. They can read and interpret graphs and tables. They recognise basic notions of likelihood.

Low International Benchmark – 400

Students have some knowledge of whole numbers and decimals, operations, and basic graphs.

TIMSS 2015 International Benchmarks of Science Achievement

Advanced International Benchmark – 625

Students demonstrate a grasp of some complex and abstract concepts in Biology, Chemistry, Physics, and Earth Science. They have an understanding of the complexity of living organisms and how they relate to their environment. They show understanding of the properties of magnets, sound, and light, as well as demonstrating understanding of structure of matter, physical and chemical properties and changes. Students apply knowledge of the solar system and of Earth's features and processes, and apply understanding of major environmental issues. They understand some fundamentals of scientific investigation and can apply basic physical principles to solve some quantitative problems. They can provide written explanations to communicate scientific knowledge.

High International Benchmark – 550

Students demonstrate conceptual understanding of some Science cycles, systems, and principles. They have some understanding of biological concepts including cell processes, human biology and health, and the inter-relationship of plants and animals in ecosystems. They apply knowledge to situations related to light and sound, demonstrate elementary knowledge of heat and forces, and show some evidence of understanding the structure of matter, and chemical and physical properties and changes. They demonstrate some understanding of the solar system, Earth's processes and resources, and some basic understanding of major environmental issues. Students demonstrate some scientific inquiry skills. They combine information to draw conclusions, interpret tabular and graphical information, and provide short explanations conveying scientific knowledge.

Intermediate International Benchmark – 475

Students recognise and communicate basic scientific knowledge across a range of topics. They demonstrate some understanding of characteristics of animals, food webs, and the effect of population changes in ecosystems. They are acquainted with some aspects of sound and force and have elementary knowledge of chemical change. They demonstrate elementary knowledge of the solar system, Earth's processes, and resources and the environment. Students extract information from tables and interpret pictorial diagrams. They can apply knowledge to practical situations and communicate their knowledge through brief descriptive responses.

Low International Benchmarks- 400

Students recognise some basic facts from the life and physical Sciences. They have some knowledge of the human body and demonstrate some familiarity with everyday physical phenomena. Students can interpret pictorial diagrams and apply knowledge of simple physical concepts to practical situations.

TIMSS 2015 Student Booklet Design

A major consequence of TIMSS' ambitious reporting goals is that many more questions are required for the assessment than can be answered by any one student in the amount of testing time available. Accordingly, TIMSS 2015 used a matrix-sampling approach that involved packaging the entire assessment pool of Mathematics and Science items at each Standard level into a set of 14 student achievement booklets, with each student completing just one booklet. Each item appears in two booklets, providing a mechanism for linking together the student responses from the various booklets. Booklets are distributed among students in participating classrooms so that the groups of students completing each booklet are approximately equivalent in terms of student ability.

TIMSS uses item-response theory scaling methods to assemble a comprehensive picture of the achievement of the entire student population from the combined responses of individual students to the booklets that they are assigned. This approach reduces to manageable proportions what otherwise would be an impossible student burden, albeit at the cost of greater complexity in booklet assembly, data collection, and data analysis.

To facilitate the process of creating the student achievement booklets, TIMSS groups the assessment items into a series of item blocks, with approximately 10-14 items in each block at the fourth Standard and 12-18 at the eighth Standard. As far as possible, within each block the distribution of items across content and cognitive domains matches the distribution across the item pool overall. As in the TIMSS 2011 assessment, TIMSS 2015 had a total of 28 blocks, 14 containing Mathematics items and 14 containing Science items. Student booklets were assembled from various combinations of these item blocks.

Following the 2011 assessment, some of the 14 Mathematics blocks and 14 Science blocks were secured for use in measuring trends in 2015. The remaining 12 blocks (6 Mathematics and 6 Science) were released into the public domain for use in publications, research, and teaching, to be replaced by newly-developed items for the TIMSS 2015 assessment. Accordingly, the 28 blocks in the TIMSS 2015 assessment comprised of blocks of trend items and blocks of new items developed for 2015. As shown in Exhibit 10, the TIMSS 2015 Mathematics blocks are labelled M01 through M14 and the Science blocks S01 through S14. Blocks with labels ending in odd numbers (01, 03, 05, etc.) contain the trend items from the 2015 assessment, as do blocks ending in 06. The remaining blocks with labels ending in even numbers contain the items developed for use for the first time in TIMSS 2015.

In choosing how to distribute assessment blocks across student achievement booklets, the major goal was to maximize coverage of the framework while ensuring that every student responded to sufficient items to provide reliable measurement of trends in both Mathematics and Science. A further goal was to ensure that achievement in the Mathematics and Science content and cognitive domains could be measured reliably. To enable linking among booklets while keeping the number of booklets to a minimum, each block appears in two booklets.

In the TIMSS 2015 booklet design, the 28 assessment blocks are distributed across 14 student achievement booklets, each student booklet consists of four blocks of items; two blocks of Mathematics items and two blocks of Science items. In half of the booklets, the two Mathematics blocks come first, followed by the two Science blocks, while in the other half the order is reversed. Additionally, in most booklets two of the blocks contain trend items from 2007 and two contain items newly developed for TIMSS 2015.

Development of the Instruments

IEA releases some items from time to time which have to be replaced. One of the National Research Coordinators' meetings was used for the construction of items, and Botswana sent two experts in Mathematics and Science to take part.

As for the 2015 assessment, items were of the select-format as well as problem-solving in an open-ended format. IEA aims at putting more emphasis on questions and tasks that offer better insight into the analytical, problem-solving and inquiry skills of students. More investigative and production-based tasks were advocated for in order to be able to cater for the cognitive domains that had been identified.

After compiling the test booklets, each country had to go through cultural adaptation of the items. This involved checking the items as presented to see if there was any cultural aspect in the items that would make it unsuitable for the intended population in the country. In such a case, a country was required to propose an amendment to that particular item that would solve the cultural concern at hand without changing the nature of the task in any way. These suggestions were then sent to IEA Headquarters in Amsterdam. The IEA secretariat appointed an independent verifier of the cultural adaptations for each country and where this verifier did not agree with the suggestions; the proposed changes could not be made. This tight control had to be maintained to ensure that countries around the world would be administering the same items.

The process of cultural adaptation included the translation from English to the language of instruction in countries that do not use English as a medium of instruction. Countries that needed to translate the tests from English to the language of instruction had to go through the verifier to make sure that the translated items were the same as the original ones in English. Botswana only made slight changes during the process of translation as its language of instruction is English.

Background questionnaires were developed for School Heads, Mathematics and Science teachers, and for the students. The piloting of the questionnaires was done at the same time with that of the Mathematics and Science items. Botswana used the parent questionnaire which it developed specifically for local use. The questionnaires were similarly subjected to cultural adaptation and translation as were the achievement items.

Piloting the Instruments

The pilot data collection in Botswana was based on Form Two students. This is because piloting was carried out in March-April 2013 and by that time Form One students had covered very little of their curriculum as the school year begins in January. The items targeted students who had completed eight years of education (students completing Form One). The TIMSS 2015 used the Form Two for both the pilot and the main survey. Test administration followed and adhered to the detailed procedure as documented in the Administration manual. This was necessary for standardisation of the procedures in all the schools and in every participating country. Administrators who were mainly retired teachers were trained on the administration procedures.

The exercise basically involved informing the schools when the instruments would be administered in their schools, and requesting the School Coordinator to prepare a place where the tests would be administered. Upon reporting to the School Head, the test administrators were taken to the School Coordinator who, in turn, took them to the test hall. The test administrators gave the correct booklet labelled with the student's identification particulars. In case a booklet was spoilt or torn, there was a procedure to follow on how to replace it. Each test booklet had two parts which were independently sealed so that while working on part one, students had no access to part two. After a short break students would return for part two, followed by the completion of the student questionnaire. While all these were going on, the School Head, Mathematics and Science teachers were busy completing their respective questionnaires.

Open-ended responses needed to be scored (coded). Thus, country representatives were trained in the diagnostic coding procedure that IEA uses for TIMSS. The Botswana National Research Coordinator and another Core Team member, who were trained by IEA trained colleagues, and selected teachers from Junior Secondary Schools, then coded the responses of the students included in the pilot sample. A sample of the scripts had to be coded by two coders each for checking on the extent of reliability of the coding exercise. Temporary research assistants were also recruited to assist with data capturing as there was massive data to be captured. The pilot data were then sent to IEA's Data Processing Centre in Hamburg, Germany. The pooled responses from piloting countries were analysed to check on how the items functioned at the pilot stage. A National Research Coordinators' workshop was convened to discuss and decide on the piloted items to be included in the 2015 assessment.

The Test Booklets for Final Data Collection

There were 14 booklets used for the final data collection. Like in the pilot, each booklet contained both Mathematics and Science items. The old and newly developed items were arranged into mutually exclusive blocks of Mathematics and Science. The estimated time for completion of each block was 15 minutes, even though the numbers of items in the blocks were not the same. Each block was systematically assigned between two to four test booklets.

Each test booklet had two parts and each part was separately sealed so that a student working on one part could not read the items for the other part. Each part had to be completed in 45 minutes.

Background Questionnaires

Just like TIMSS 2011, TIMSS 2015 had five questionnaires: student questionnaire, Mathematics teacher questionnaire, Science teacher questionnaire, school questionnaire and curriculum questionnaire. Botswana opted for an additional parent questionnaire. The student questionnaire elicited background information from students, including their aspirations and attitudes towards Mathematics and Science.

The teacher questionnaire sought information from the teacher as to the curriculum that was actually implemented at classroom level, the academic and professional background of the teacher, their instructional practices and attitudes towards the subject. The School Head was requested to provide background information of the school, such as enrolment, number of teachers, facilities, etc. The NRC provided information on curriculum questionnaire about the objectives in the frameworks as to whether they were in the curriculum. The parent questionnaire sought the background information from the parents relating to the education of their child.

Main Survey Data Collection

The data collection schedule was sent to the sampled schools for the main data collection. Instruments and other documents required for each school were printed and packed. The test booklet for each student was labelled with his/her name and identity number. Just like during piloting, the administrators had to strictly adhere to the instructions in the administration manual.

The process of data collection for the main survey was the same as the pilot data collection. The same officers who participated in the pilot data collection were reinforced with newly trained test administrators (teachers) so as to be able to cover all the schools within the scheduled two weeks. The final instruments were administered to Form Two students in October-November, 2014. Though the TIMSS project was for 2015, Southern Hemisphere countries had to collect their data earlier due to the structure of their school calendar, while Northern Hemisphere countries collected theirs in May/June 2015 coinciding with their school year ended.

One expert in assessment was identified and sent to the Secretariat Head Office in Amsterdam for training as an International Quality Control Monitor (IQCM). This IQCM operated independently and was fully supported by IEA financially during the data collection to ensure minimal contact between her and the project team. His report indicated great adherence to the administration procedures. Three other Quality Control Monitors were trained by the National Research Coordinator (NRC) and supported through the project funds. The idea was to increase coverage of the testing centres as recommended by IEA. Indeed, most of the centres were visited and these National Quality Control Monitors came back with very impressive reports on how the test administrators handled their work.

The teachers and officers who coded the pilot scripts were engaged in coding the open-ended responses for the main survey. As in the pilot sample, some of the scripts were double-coded to assess the reliability of the coding exercise. These reliability scripts were eventually sent to DPC at Hamburg for scanning so that the scripts would be available for future coding.

The curriculum questionnaire was responded to by the coders under the leadership of a curriculum development officer as they constituted the body of practitioners who knew what was in the curriculum up to Form One level of education. Responses were then transmitted to DPC online.

Data Capture and Cleaning

More temporary data capturing assistants were engaged in capturing data in addition to those who captured for the pilot. Data was subsequently sent to DPC. Throughout the study, IEA took measures to enhance the quality of the data collected from each country. A booklet was produced to give guidance on data entry so that the structure of the data was the same from country to country. Once received, DPC went through extensive data cleaning procedures, and corresponded with NRCs to clear emerging queries. Considering the massive data captured, Botswana data were relatively clean and there were no major concerns raised by the DPC.

Data Analysis and Report Writing

The data from DPC scored students' responses and the development of the scales for reporting. Item Response Theory (IRT) models were used for item and persons' parameter estimates. The three-parameter model was used for multiple-choice items scored correct/incorrect; the two-parameter model was used for free-response items scored correct/incorrect and the partial credit model was used for polytomous free-response items with two or more score points. IRT allows the performance of students to be summarised on a common metric or scale even though individual students did not respond to the same items. A scale average was set at 500 (as the mean) and a standard deviation of 100. Rather than a single value of ability estimate for each student on each scale, plausible values were generated and five of these were used for obtaining mean values for specified groups.

Because of lack of random sampling and the use of plausible values, SPSS could not be used directly for obtaining mean values and percentages. IEA studies use SPSS sitting on the International database Analyser (IDB Analyser) platform.

Interpretation of Results

(a) Means, standard error and significant differences

The results are mostly presented in tables indicating percentages and means of students in various groups; the standard errors of these percentages and means. Where subgroups are compared, mean differences and the standard error of the mean differences are reported. Standard errors indicate the extent of the accuracy of an estimation of the mean or mean difference. An example is presented in Table 2.5.

Table 2.5: *Table showing how to interpret the results*

Region	n	%	Science			Mathematics		
			Mean	SE	SD	Mean	SE	SD
Central	1 977	36.40	384.96	4.17	105.55	385.57	3.66	81.52
Chobe	90	1.16	400.40	10.21	112.47	391.17	8.64	82.70
Ghanzi	110	2.17	379.59	16.71	109.77	384.61	15.57	76.97
Kgalagadi	173	2.71	344.01	7.46	112.55	359.41	3.69	82.91

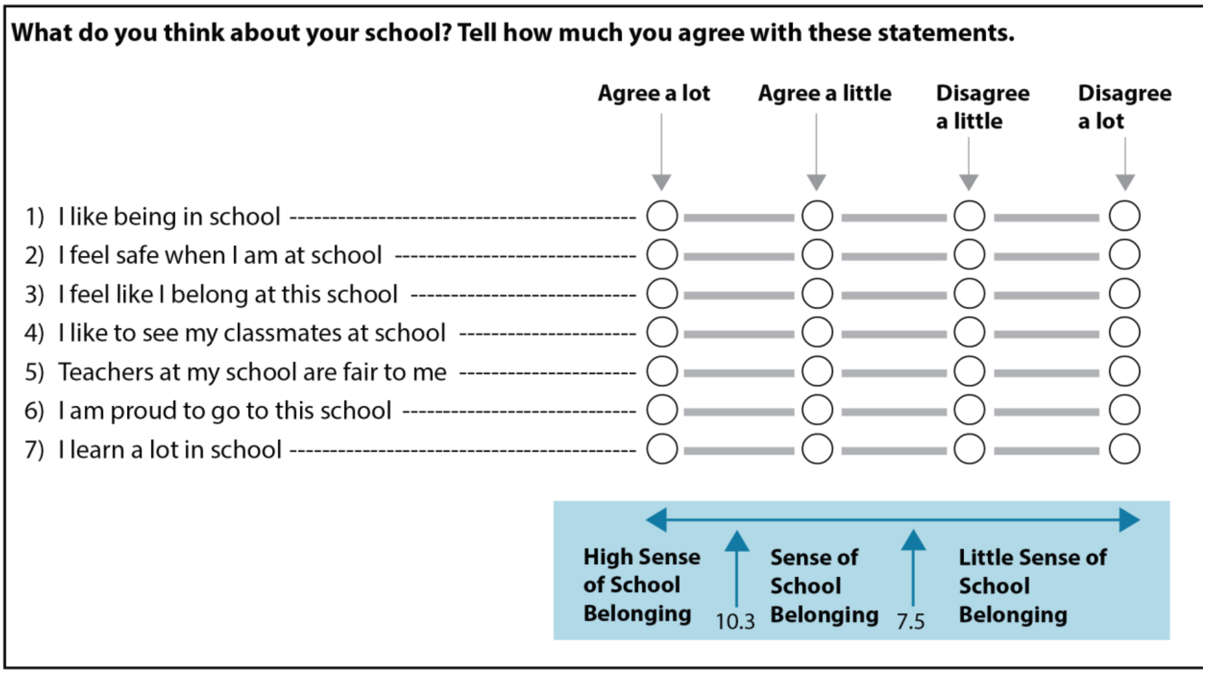
The *n* is the number of students in each category and the % is the percentage they constitute. The Science mean score of 384.96 with a standard error of 4.17 means that the mean could be between 380.79 and 389.13. Mean differences (**Diff)** is sometimes reported for checking whether subgroup differences are significant. A significant mean difference (Diff) is indicated by an asterisks (*).

(b) Indices

Many of the TIMSS 2015 context questionnaire items were developed to be combined into scales measuring a single underlying latent construct. For reporting, the scales were constructed using Item Response Theory (IRT) scaling methods, specifically the Rasch partial credit model. As a parallel to the TIMSS International Benchmarks of achievement, each context scale allowed students to be classified into regions corresponding to high, middle, and low values on the construct. To facilitate interpretation of the regions, the cut-points delimiting the regions were defined in terms of combinations of response categories.

As an example illustrating the TIMSS approach to reporting context questionnaire data, Figure 2.1 presents the TIMSS 2015 *Students' Sense of School Belonging* scale.

This scale seeks to measure students' feelings towards their school and connectedness with the school community.



Source: TIMSS 2015
Figure 2.1: *Items in the TIMSS 2015 Students' Sense of School Belonging Scale, Eighth Grade*

For each of the seven statements, students were asked to indicate the degree of their agreement with the statement: agree a lot, agree a little, disagree a little, or disagree a lot. Using IRT partial credit scaling, the data from student responses were placed on a scale constructed so that the scale center point of 10 was located at the mean score across all TIMSS countries. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation across all countries.

Students with a High Sense of School Belonging had a scale score greater than or equal to the point on the scale, 10.3 in this case, corresponding to agreeing a lot, on average, with four of the seven statements and agreeing a little with three of the statements. Students with Little Sense of School Belonging had a score no higher than the point (7.5) on the scale corresponding to disagreeing a little with four of the statements, on average, and agreeing a little with three of them.

CHAPTER THREE: ASSESSMENT FRAMEWORKS AND CURRICULUM MATCH

Assessment Frameworks and Item Development

Test items were based on the international frameworks developed interactively and iteratively by all participating countries. For each curriculum area at each grade, the frameworks were organized around two dimensions: a content dimension specifying the content to be assessed and a cognitive dimension specifying the thinking processes to be assessed. National Research Coordinators (NRCs) together with Subject matter specialists participated in the development and review of the assessment frameworks; test items; scoring guide; and piloting.

The following content and cognitive domains together with their weightings presented in Tables 3.1 and 3.2 were identified to be appropriate for TIMSS test (Gronmo, Lindquist, Arora & Mullis, 2013; Jones, Wheeler, Centurino, 2013). It should be noted that the TIMSS assessment contained about 200 items for each curriculum area, of which majority of the items assessed students' Applying and Reasoning skills.

Table 3.1: *Target Percentages of the TIMSS 2015 Mathematics and Science Assessment Devoted to Content Domains at the Eighth Grade*

Mathematics		Science	
Content Domains	%	Content Domains	%
Number	30%	Biology	35%
Algebra	30%	Chemistry	20%
Geometry	20%	Physics	25%
Data and Chance	20%	Earth Science	20%

Source: TIMSS 2015 Assessment Frameworks

Table 3.2: *Target Percentages of the TIMSS 2015 Mathematics and Science Assessment Devoted to Cognitive Domains at the Eighth Grade*

Cognitive Domains	Percentages	
	Science	Mathematics
Knowing	35%	35%
Applying	35%	40%
Reasoning	30%	25%

Source: TIMSS 2015 Assessment Frameworks

Table 3.3 shows the distribution of items included in the assessment by content domain, and item format. It can be noted that in Mathematics, Algebra had the highest number of multiple choice items (35) and Geometry the least (22). In terms of the constructed response items, Number had the highest items (35) and Data and Chance the least (14). However, Number constituted the highest proportion of the test with 31% of the score points and Geometry and Data and Chance the least with 21% each. The proportion of multiple choice and constructed response items were almost the same. The Mathematics test had in total 212 items or 229 score points.

Table 3.3: *Distribution of Mathematics Test Items by Content Domains and Item Format*

	Domain	Multiple choice items	Constructed response items	Total Items	Percentage of score points
	Number	29 (29)	35 (41)	64 (70)	31%
	Algebra	35 (35)	27 (30)	62 (65)	28%
	Geometry	22 (22)	21 (25)	43 (47)	21%
Mathematics	Data and Chance	29 (31)	14 (16)	43 (47)	21%
	Total	115 (117)	97 (112)	212 (229)	100%
	Percentage of score points	51%	49%		
Science	Biology	36 (36)	39 (51)	75 (87)	36%
	Chemistry	23 (24)	21 (22)	44 (46)	19%
	Physics	33 (34)	23 (23)	56 (57)	24%
	Earth Science	29 (30)	16 (19)	45 (49)	21%
	Total	121 (124)	99 (115)	220 (239)	100%
	Percentage of score points	52%	48%		

() Figures in brackets represent score points

Source: TIMSS 2015 Assessment Frameworks

In Science, Biology had the highest number of multiple choice items (36) and Chemistry had the least (23). In terms of the constructed response items, still Biology had the highest items (39) and Earth Science had the least (16). Biology constituted the highest proportion of the test with 36% of the score points and Chemistry the least with 19%. The proportion of multiple choice and constructed response items were almost the same. The Science test had in total 220 items or 239 score points.

Table 3.4 shows the distribution of items included in the assessment by cognitive domain and item format. Application constituted the highest number of items (almost half) and there were almost the same proportion of multiple choice to constructed response score points in both subjects.

Table 3.4: *Distribution of Test Items by Cognitive Domains and Item Format*

Subject	Domain	Multiple choice items	Constructed response items	Total Items	Percentage of score points
Mathematics	Knowing	50 (50)	19 (20)	69 (70)	31%
	Applying	48 (48)	47 (55)	95 (103)	45%
	Reasoning	17 (19)	31 (37)	48 (56)	24%
	Total	115 (117)	97 (112)	212 (229)	100%
	Percentage of score points	51%	49%		
Science	Knowing	64 (66)	13 (19)	77 (85)	36%
	Applying	44 (45)	47 (53)	91 (98)	41%
	Reasoning	13 (13)	39 (43)	52 (56)	23%
	Total	121 (124)	99 (115)	220 (239)	100%
	Percentage of score points	52%	48%		

() Figures in brackets represent score points

Source: TIMSS 2015 Assessment Frameworks

Congruence between Curriculum and Assessment Frameworks

For a country to be allowed to participate in TIMSS, its National Curriculum should match at least 70% of the International Assessment Frameworks. The match between Botswana curricula and the international frameworks was found by experts to be 94% and 88% for Mathematics and Science respectively. The Botswana Encyclopaedia chapter in *TIMSS 2015 Encyclopedia* summarizes Mathematics and Science curricula, instructional practices, and teacher education requirements that were used for comparison with the international assessment frameworks.

To further ascertain the congruence between the international assessment frameworks and the country's curriculum, each country conducted curriculum test match analysis to identify the items/score points out of the total TIMSS items/score points coming directly from its curricula. Botswana identified 207 items/score points out of 221 and 197 items/score points out of 233 for Mathematics and Science respectively, to be directly coming from its curricula. Botswana's performance on the TIMSS test was 23% and 29% in Mathematics and Science respectively. On items identified to be coming from its curricula, Botswana scored the same (23% for Mathematics and 28% for Science) as in the TIMSS test. Botswana students were thus not only unable to achieve high scores in the total TIMSS items but also on their own curricula, an indication that Botswana curriculum was at par with international standards. This point to the fact that there are therefore some other circumferential factors, apart from the curricula, that hindered high achievement in their own curricula.

Figures 3.1 and 3.2 below are excerpts showing a selected participating country's percentage of correct items on the whole test and on the items identified to be addressing their curriculum. Column 2 shows the average percent correct for each country on the whole test. It is indicated that Botswana's percent correct to be 23% and 28% on Mathematics and Science respectively. Column 7 shows percent correct for Botswana on other countries' items identified to be from their national curricula as well as performance on items Botswana identified as coming from its curricula. For example, Botswana scored 28% on Chile curriculum, 22% on Morocco curriculum and 23% on its own curriculum in Mathematics.

The very last row labelled 'number of items (score points) identified' indicates the number of items/score points from each country and from the total TIMSS test. This shows that indeed the country's curriculum highly matched the international frameworks, as was the case for most of the countries. Thus, no country could attribute its performance to favourable or unfavourable frameworks.

Country	Average Percent Correct on All Items	Chile	Oman	Kuwait	Jordan	Botswana (9)	Morocco	South Africa (9)	Saudi Arabia	Benchmarking Participants	Quebec, Canada	Ontario, Canada	Dubai, UAE	Florida, US	Abu Dhabi, UAE
Chile	28 (0.5)	29	29	29	32	28	28	28	28		29	30	28	28	29
Oman	26 (0.4)	26	26	27	30	26	26	26	26		26	27	26	26	26
Kuwait	24 (0.8)	24	24	24	27	24	24	24	24		24	25	24	24	24
Jordan	23 (0.4)	23	23	24	27	23	23	23	23		23	24	23	23	23
Botswana (9)	23 (0.3)	24	24	24	27	23	23	23	23		23	25	23	23	23
Morocco	22 (0.3)	22	22	22	25	22	22	22	22		22	23	22	22	22
South Africa (9)	21 (0.7)	22	22	22	24	21	21	21	21		21	23	21	21	21
Saudi Arabia	21 (0.6)	21	20	21	24	21	20	21	21		20	22	21	21	21
International Avg.	42 (0.1)	43	43	43	45	42	42	42	42		42	44	42	42	42
Benchmarking Participants															
Quebec, Canada	54 (1.0)	57	57	56	58	55	55	54	54		56	58	54	54	55
Ontario, Canada	49 (0.8)	51	50	50	52	49	49	49	49		50	53	49	49	50
Dubai, UAE	47 (0.5)	48	48	48	51	48	47	47	47		48	49	47	47	48
Florida, US	43 (1.5)	43	43	43	47	43	42	43	43		43	45	43	43	43
Abu Dhabi, UAE	32 (0.9)	33	33	33	36	33	33	32	32		33	34	32	32	33
Number of Items (Score Points) Identified*	221	193	194	207	183	207	181	221	221		205	184	221	218	215

Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015
Figure 3.1a: *Excerpt of Selected Countries Test Curriculum Match Analysis for Mathematics*

Country	Average Percent Correct on All Items	Georgia	Jordan	Kuwait	Lebanon	Botswana (9)	Saudi Arabia	Morocco	South Africa (9)	Benchmarking Participants	Dubai, UAE	Quebec, Canada	Ontario, Canada	Florida, US	Abu Dhabi, UAE
Georgia	35 (0.5)	35	36	34	35	34	35	34	35		35	34	34	35	34
Jordan	33 (0.4)	32	35	33	33	32	33	32	33		35	33	32	33	32
Kuwait	31 (0.8)	30	32	30	31	30	31	30	31		32	31	31	31	30
Lebanon	29 (0.7)	29	30	29	31	29	29	28	29		31	28	28	29	28
Botswana (9)	28 (0.3)	28	30	29	27	29	28	27	28		28	28	29	29	28
Saudi Arabia	28 (0.6)	28	30	28	27	28	28	28	28		30	28	29	28	28
Morocco	27 (0.3)	26	28	27	27	26	27	27	27		27	27	25	27	26
South Africa (9)	24 (0.7)	24	26	24	23	24	24	23	24		24	24	24	24	23
International Avg.	44 (0.1)	43	45	43	43	43	44	42	44		44	44	44	44	43
Benchmarking Participants															
Dubai, UAE	50 (0.4)	50	52	50	50	50	50	50	50		52	50	51	50	50
Quebec, Canada	50 (0.9)	50	52	49	49	48	50	48	50		52	52	50	50	49
Ontario, Canada	49 (0.5)	48	50	48	46	48	49	46	49		50	49	50	49	48
Florida, US	46 (1.2)	46	48	46	45	46	46	45	46		49	47	48	46	47
Abu Dhabi, UAE	38 (0.9)	37	39	37	37	37	38	37	38		40	38	38	37	38
Number of Items (Score Points) Identified*	233	192	213	216	111	197	232	152	233		67	176	108	224	180

Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015.
Figure 3.1b: *Excerpt of Selected Countries Test Curriculum Match Analysis for Science*

It should be noted that since frameworks are just guidelines, it does not mean that by the time the students write the TIMSS test they would have done all the topics. For example, Singapore was the highest-achieving country for Science in year 8, but it had taught only seven of the 23 TIMSS topics by the time these pupils took their TIMSS assessments (Greany, Barnes, Mostafa, Pensiero, Swensson, 2016).

CHAPTER FOUR: STUDENTS ACHIEVEMENT

Overall Performance

Botswana has been participating in TIMSS since 2003. The country has therefore participated in four TIMSS cycles. The mean score for 2015 cycle is shown in Figure 4.1. The mean score for Mathematics was 390.84 and that of Science was 391.80. Thus Botswana students scored below the scale centre point of 500 in both Mathematics and Science.

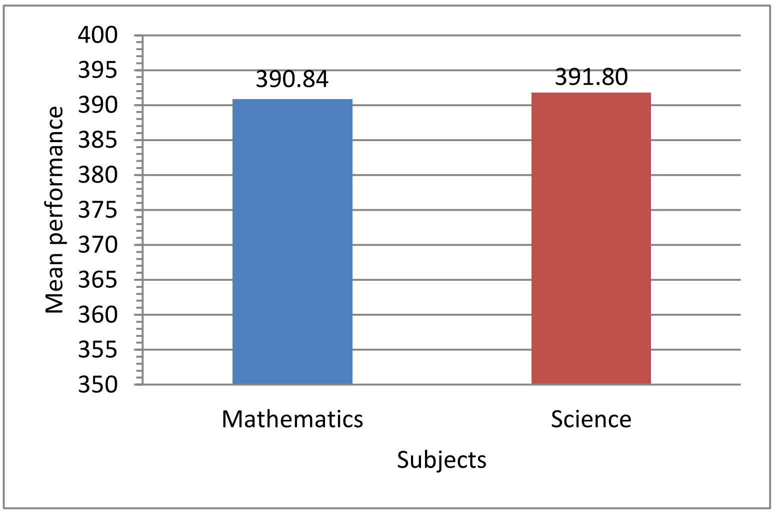
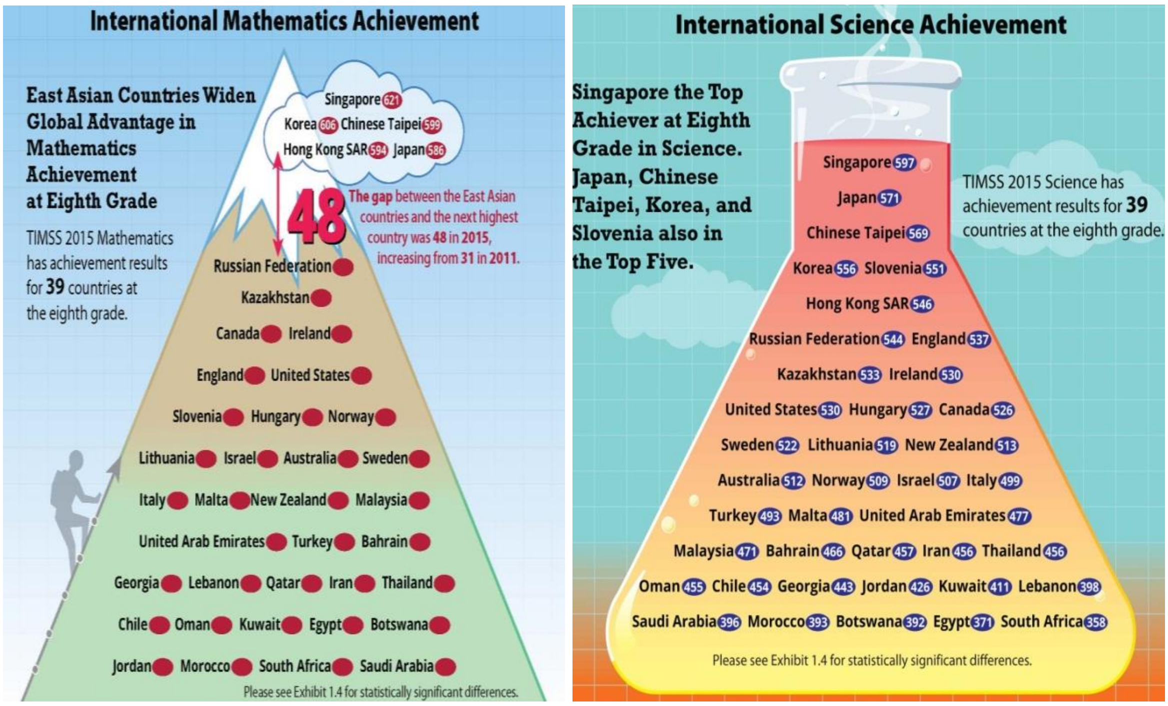


Figure 4.1: *Overall Performance for Mathematics and Science*

Botswana's performance in Mathematics and Science relative to other participating countries is presented in Figure 4.1. Botswana was one of the least performing countries in TIMSS 2015.



Source: IEA's trends in international mathematics and science study –TIMSS 2015.

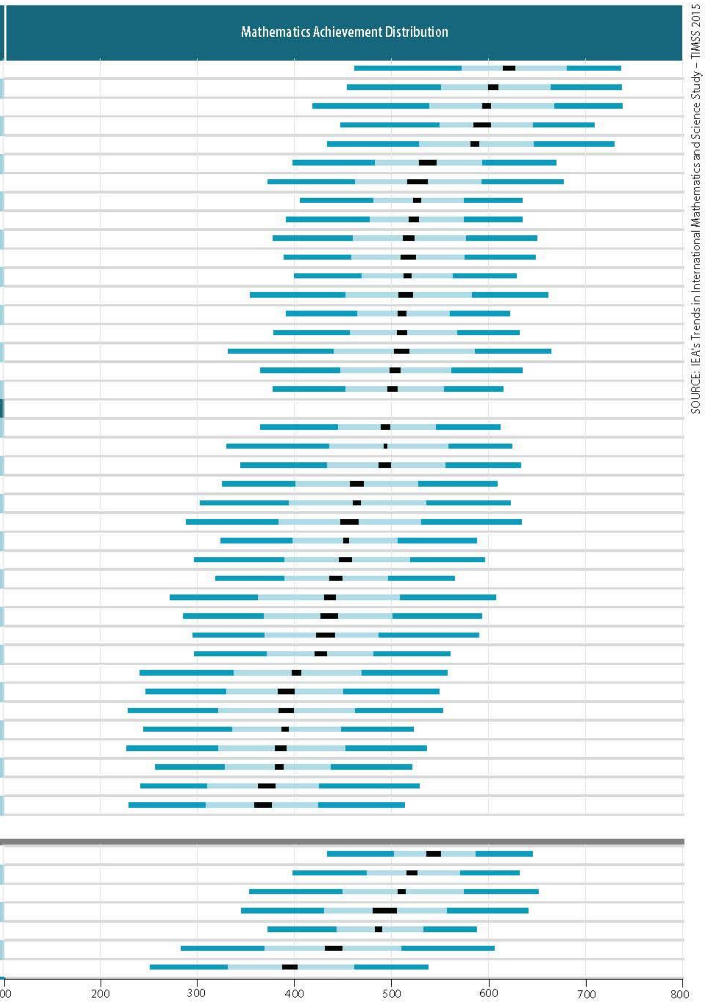
Figure 4.2: *Participating Countries Achievement in Mathematics and Science at a Glance*

Figure 4.2, adapted from the TIMSS 2015 International report, shows the country's relative standing among the participating countries in both Mathematics and Science. The East Asian countries were the highest performing in both Mathematics and Science. Note the gap of 48 points between the East Asian countries and the next highest country, Russian Federation, increasing from 31 in 2011 for Mathematics.

TIMSS 2015 Mathematics 8th Grade

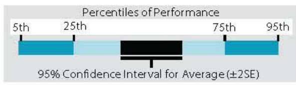
Exhibit 1.2: Distribution of Mathematics Achievement

Country	Average Scale Score	
2 Singapore	621 (3.2)	▲
Korea, Rep. of	606 (2.6)	▲
Chinese Taipei	599 (2.4)	▲
Hong Kong SAR	594 (4.6)	▲
Japan	586 (2.3)	▲
Russian Federation	538 (4.7)	▲
Kazakhstan	528 (5.3)	▲
1 † Canada	527 (2.2)	▲
Ireland	523 (2.7)	▲
† United States	518 (3.1)	▲
England	518 (4.2)	▲
Slovenia	516 (2.1)	▲
Hungary	514 (3.8)	▲
Norway (9)	512 (2.3)	▲
2 Lithuania	511 (2.8)	▲
3 Israel	511 (4.1)	▲
Australia	505 (3.1)	
Sweden	501 (2.8)	
TIMSS Scale Centerpoint	500	
2 Italy	494 (2.5)	▼
Malta	494 (1.0)	▼
† New Zealand	493 (3.4)	▼
Malaysia	465 (3.6)	▼
United Arab Emirates	465 (2.0)	▼
Turkey	458 (4.7)	▼
Bahrain	454 (1.4)	▼
1 2 Georgia	453 (3.4)	▼
Lebanon	442 (3.6)	▼
ψ Qatar	437 (3.0)	▼
ψ Iran, Islamic Rep. of	436 (4.6)	▼
Thailand	431 (4.8)	▼
ψ Chile	427 (3.2)	▼
ψ Oman	403 (2.4)	▼
ψ Kuwait	392 (4.6)	▼
ψ Egypt	392 (4.1)	▼
ψ Botswana (9)	391 (2.0)	▼
Ж Jordan	386 (3.2)	▼
Ж Morocco	384 (2.3)	▼
Ж South Africa (9)	372 (4.5)	▼
Ж Saudi Arabia	368 (4.6)	▼
Benchmarking Participants		
‡ Quebec, Canada	543 (3.9)	▲
Ontario, Canada	522 (2.9)	▲
Dubai, UAE	512 (2.1)	▲
1 Florida, US	493 (6.4)	
Norway (8)	487 (2.0)	▼
Abu Dhabi, UAE	442 (4.7)	▼
† Ж Buenos Aires, Argentina	396 (4.2)	▼



▲ Country average significantly higher than the centerpoint of the TIMSS 8th grade scale

▼ Country average significantly lower than the centerpoint of the TIMSS 8th grade scale



The TIMSS achievement scale was established in 1995 based on the combined achievement distribution of all countries that participated in TIMSS 1995. To provide a point of reference for country comparisons, the scale centerpoint of 500 was located at the mean of the combined achievement distribution. The units of the scale were chosen so that 100 scale score points corresponded to the standard deviation of the distribution.

Ж Reservations about reliability because the percentage of students with achievement too low for estimation exceeds 25%.

ψ Reservations about reliability because the percentage of students with achievement too low for estimation exceeds 15% but does not exceed 25%.

See Appendix C.2 for target population coverage notes 1, 2, and 3. See Appendix C.8 for sampling guidelines and sampling participation notes †, ‡, and ‡.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

Source: IEA's Trends in International Mathematics and Science Study –TIMSS 2015.

Figure 4.3: *Distribution of Mathematics Achievement*

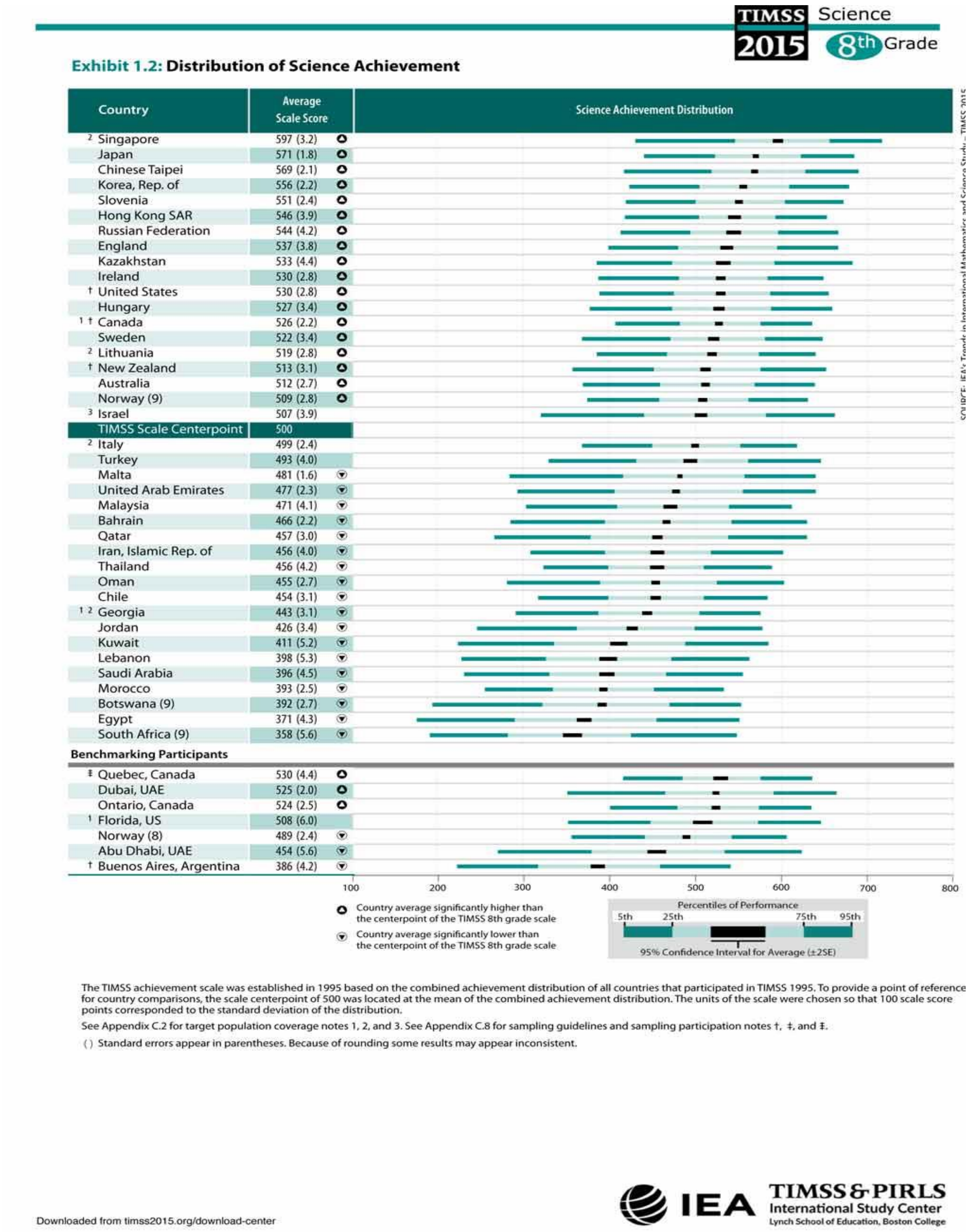


Exhibit 1.2: Distribution of Science Achievement

Country	Average Scale Score	
[2] Singapore	597 (3.2)	Significantly higher
Japan	571 (1.8)	Significantly higher
Chinese Taipei	569 (2.1)	Significantly higher
Korea, Rep. of	556 (2.2)	Significantly higher
Slovenia	551 (2.4)	Significantly higher
Hong Kong SAR	546 (3.9)	Significantly higher
Russian Federation	544 (4.2)	Significantly higher
England	537 (3.8)	Significantly higher
Kazakhstan	533 (4.4)	Significantly higher
Ireland	530 (2.8)	Significantly higher
† United States	530 (2.8)	Significantly higher
Hungary	527 (3.4)	Significantly higher
[1] † Canada	526 (2.2)	Significantly higher
Sweden	522 (3.4)	Significantly higher
[2] Lithuania	519 (2.8)	Significantly higher
† New Zealand	513 (3.1)	Significantly higher
Australia	512 (2.7)	Significantly higher
Norway (9)	509 (2.8)	Significantly higher
[3] Israel	507 (3.9)	
TIMSS Scale Centerpoint	500	
[2] Italy	499 (2.4)	
Turkey	493 (4.0)	
Malta	481 (1.6)	Significantly lower
United Arab Emirates	477 (2.3)	Significantly lower
Malaysia	471 (4.1)	Significantly lower
Bahrain	466 (2.2)	Significantly lower
Qatar	457 (3.0)	Significantly lower
Iran, Islamic Rep. of	456 (4.0)	Significantly lower
Thailand	456 (4.2)	Significantly lower
Oman	455 (2.7)	Significantly lower
Chile	454 (3.1)	Significantly lower
[1 2] Georgia	443 (3.1)	Significantly lower
Jordan	426 (3.4)	Significantly lower
Kuwait	411 (5.2)	Significantly lower
Lebanon	398 (5.3)	Significantly lower
Saudi Arabia	396 (4.5)	Significantly lower
Morocco	393 (2.5)	Significantly lower
Botswana (9)	392 (2.7)	Significantly lower
Egypt	371 (4.3)	Significantly lower
South Africa (9)	358 (5.6)	Significantly lower
Benchmarking Participants		
‡ Quebec, Canada	530 (4.4)	Significantly higher
Dubai, UAE	525 (2.0)	Significantly higher
Ontario, Canada	524 (2.5)	Significantly higher
[1] Florida, US	508 (6.0)	
Norway (8)	489 (2.4)	Significantly lower
Abu Dhabi, UAE	454 (5.6)	Significantly lower
† Buenos Aires, Argentina	386 (4.2)	Significantly lower

Country average significantly higher than the centerpoint of the TIMSS 8th grade scale

Country average significantly lower than the centerpoint of the TIMSS 8th grade scale

The TIMSS achievement scale was established in 1995 based on the combined achievement distribution of all countries that participated in TIMSS 1995. To provide a point of reference for country comparisons, the scale centerpoint of 500 was located at the mean of the combined achievement distribution. The units of the scale were chosen so that 100 scale score points corresponded to the standard deviation of the distribution.

See Appendix C.2 for target population coverage notes 1, 2, and 3. See Appendix C.8 for sampling guidelines and sampling participation notes †, ‡, and ‡.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

IEA TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College

Source: IEA's Trends in International Mathematics and Science Study –TIMSS 2015.

Figure 4.4: *Distribution of Science Achievement*

Comparison with the previous cycles shows a decline in performance, ever since the country started participating in 2003 as shown in Figure 4.5 below. Performance from 2003 to 2007 dropped from 366.2 to 363 for Mathematics while for Science it dropped from 364.6 to 354.5. It is worth noting that the declining trend continues even at Form Two level.

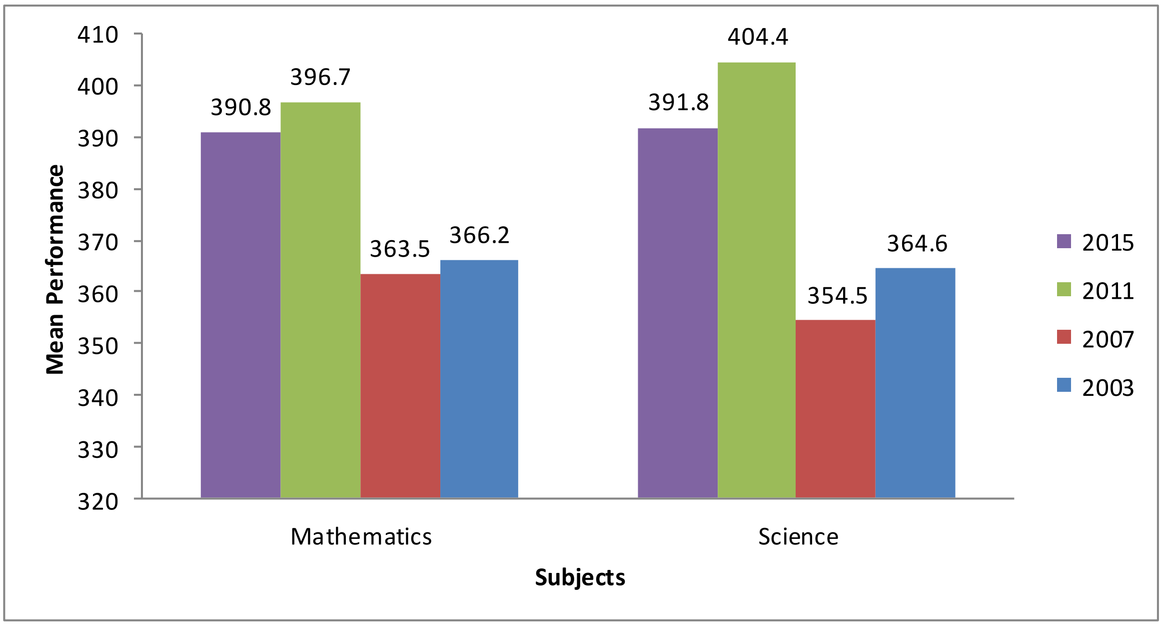


Figure 4.5: *Overall Performance Trend*

Performance by Botswana continues to drop against improvement internationally, despite a number of interventions introduced as a result of previous TIMSS findings (See Figure 4.6). Among the interventions introduced, they include curriculum review to be aligned with international standards, training teachers on setting High Order Thinking Skills items, introduction of Strengthening of Mathematics and Science in Secondary Education programme (SMASSE) (Masole, Gabalebatse, Guga, & Pharithi, 2016).

Source: IEA's trends in international mathematics and science study – TIMSS 2015.

Figure 4.6: *International Trends Performance*

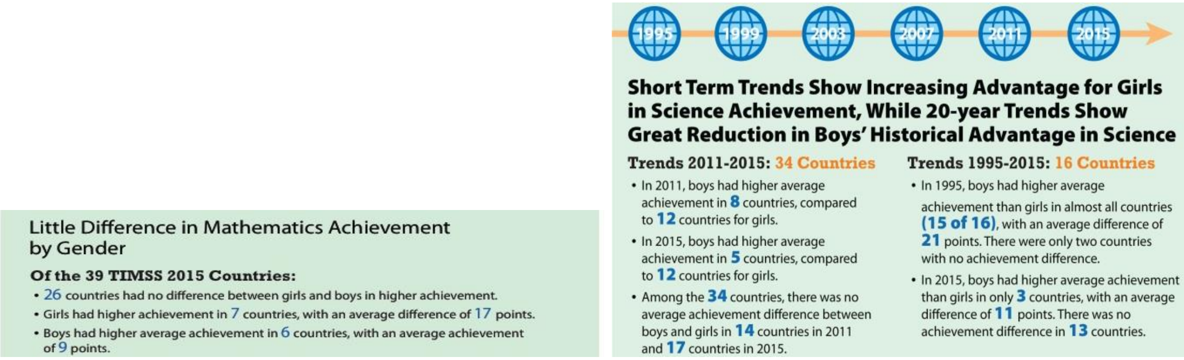
Performance by Gender

Table 4.1 presents TIMSS results by gender. Girls scored relatively higher than boys in both Mathematics and Science. The average performance for girls was 400.3 compared to 381.1 for boys in Mathematics while in Science the average performance for girls was 402.6 compared to 380.7 for boys.

Table 4.1: *Comparison Between Boys and Girls Performance*

Subject	Gender	Mean Performance	SE	Significance
Mathematics	Girls	400.3	3.3	Girls performance statistically significantly higher than boys
	boys	381.1	3.3	
Science	Girls	400.6	2.5	Girls performance statistically significantly higher than boys
	boys	381.7	2.5	

This result compares well with the international picture, although the majority of the countries showed no differences in performance between boys and girls, except for seven countries which showed higher performance by girls, compared to two countries showing higher performance by boys in Mathematics. In Science, girls had higher achievement in 14 countries with an average difference of 28 points, while boys had higher achievement in 5 countries with an average of 11 points. But 20 countries showed no differences in average performance between boys and girls.



Source: IEA's Trends in International Mathematics and Science Study –TIMSS 2015.

Figure 4.7: *Trend Performance by Gender in all Cycles*

The figure shows that girls always outperform boys. Botswana is the second country with the highest significant differences between girls and boys performance in Mathematics. A close inspection reveals that almost all, if not all the countries in which girls performed significantly better than boys were from Asia and Africa.

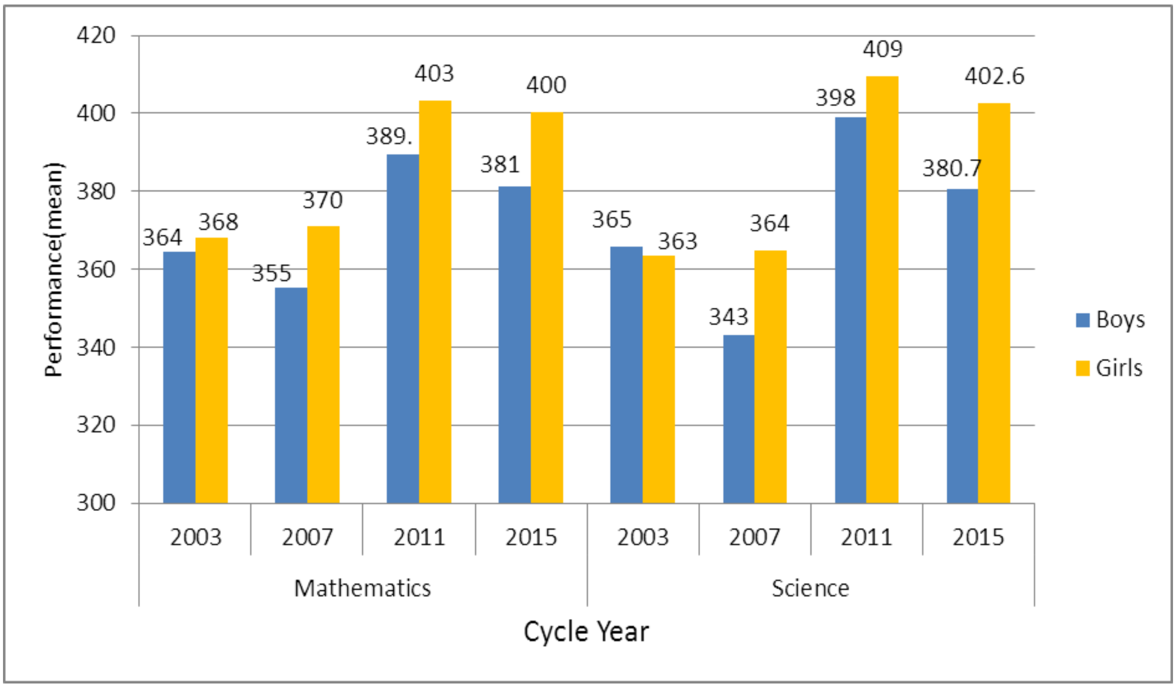


Figure 4.8*: Trends in Performance by Gender*

A number of studies have found that girls in Botswana outperform boys significantly even in national examinations (Ministry of Education, 2001; Mogapi, 2013a; Ministry of Education & Skills Development, 2011; Ministry of Education & Skills Development, 2006; Ministry of Education & Skills Development, 2009). Internationally, however, the difference seems to be disappearing. For example, in TIMSS 2015 Mathematics, 26 out of the 39 countries that participated had the same performance between girls and boys, whilst girls had higher achievement in 7 countries, compared to 6 countries in which boys outperformed girls (IEA-TIMSS 2015).

Performance by Content and Cognitive domains

Since the international frameworks were organised around content and cognitive domains (see Tables 3.1 and 3.2 in Chapter 3), analysis was therefore conducted according to these domains.

(i) Mathematics Performance by Content and Cognitive Domains

Students performed best in Algebra (399.8) and least in Data and Chance (373.6) content domains as depicted in Figure 4.9. Performance by cognitive domain shows that students performed relatively well in Mathematics knowledge items, with an average score of 393.56 and least in application items with an average score of 385.38.

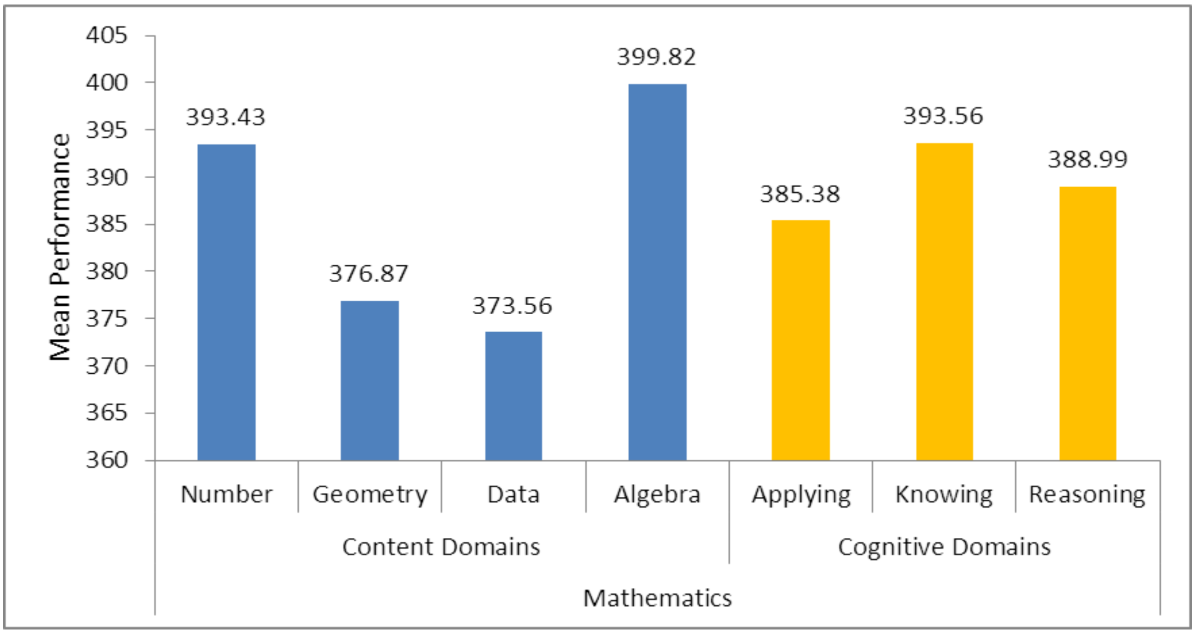


Figure 4.9*: Mathematics Performance by Content and Cognitive Domains*

Table 4.2: *Performance by Mathematics Content and Cognitive Domains*

Subject	Domain	Mean Performance	SE	Significance
Content	Number	393	3.2	No significant difference from overall score
	Algebra	400	2.3	Significantly higher than overall score
	Geometry	377	2.5	Significantly lower than overall score
	Data and Chance	374	3.1	Significantly lower than overall score
Cognitive	Knowing	394	3.0	No significant difference from overall score
	Applying	385	2.3	Significantly lower than overall score
	Reasoning	389	2.0	No significant difference from overall score

Compared to the previous cycle (2011) performance was found not to be significantly different in three content domains with the exception of Data and Chance (See Table 4.2).

Table 4. 3: *Performance by Mathematics Content Domains Compared to the Previous Cycle*

Cycle	Content Domain Means			
	Number (SE)	Algebra (SE)	Geometry (SE)	Data and Chance (SE)
2015	393.43 (3.22)	399.82 (2.31)	376.87 (2.52)	373.56 (3.14)
2011	392.07(3.27)	406.81(3.21)	380.68(2.98)	390.67(3.20)
Difference from 2011	1	-7	-4	-17
2015 Diff from overall score (391)	3	9	-14	-17

The difference between Mathematics overall score (390.8) and each content domain score revealed that Geometry and Data and Chance had the highest negative difference of -14 and -17 respectively, meaning that they were 14 points and 17 points respectively lower than the overall mean score. Thus these two content domains were more difficult for the students than the others.

(ii) Science Performance by Content and Cognitive Domains

Students performed best in Biology (396.6) and least in Earth Science (368.4) as shown in Figure 4.10 below. In terms of cognitive domain, students performed well in science application items, with an average score of 398.49 and least in knowledge items, with an average score of 371.27. This finding is somewhat contrary to expectations as knowledge domain is the lowest of the three in terms of the cognitive demand. Similar trends were observed in the TIMSS previous cycles (Ministry of Education & Skills Development, (2006); Ministry of Education & Skills Development, (2009); Ministry of Education & Skills Development, (2015).

Performing poorer in knowledge domain is not peculiar to Botswana as this was observed internationally. In TIMSS 2015, this was the case for 23 countries out of 39 that participated in the study. A similar trend was also observed in Mathematics where 16 countries out of 39 scored higher in application items than in knowledge items.

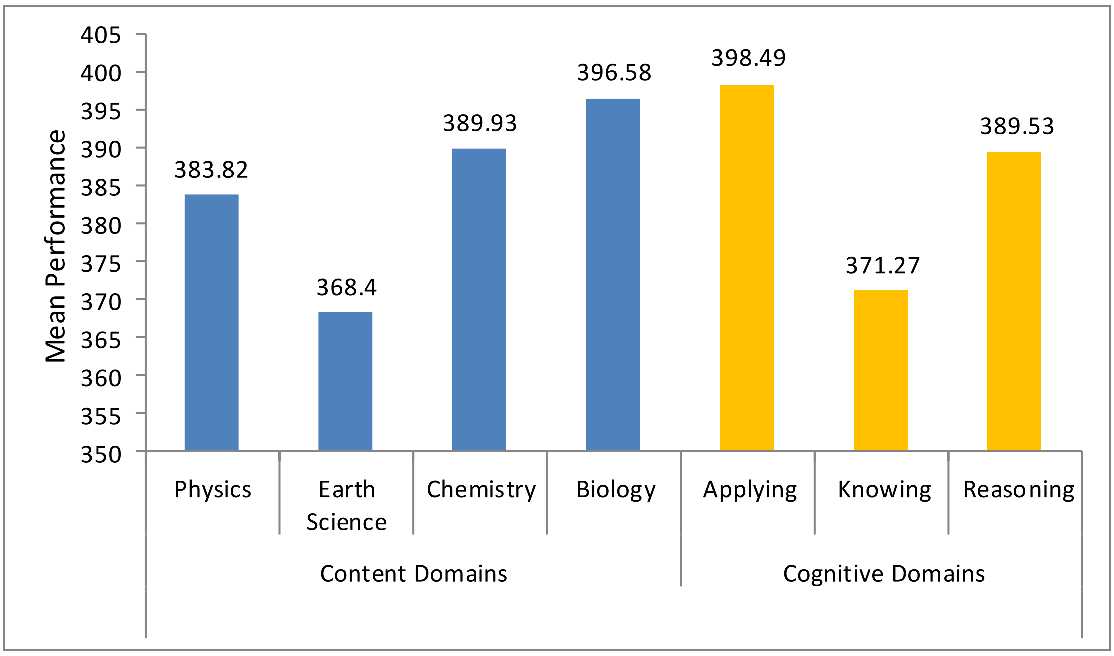


Figure 4.10: *Science Performance by Content and Cognitive Domains*

Table 4.4: *Performance by Science Content and Cognitive Domains*

Subject	Cognitive Domain	Mean Performance	SE	Significance
Content	Biology	397	2.9	Significantly higher than overall score
	Chemistry	390	3.6	No significant difference from overall score
	Physics	384	2.8	Significantly lower than overall score
	Earth Science	368	3.1	Significantly lower than overall score
Cognitive	Knowing	371	3.6	Significantly lower than overall score
	Applying	398	3.8	Significantly higher than overall score
	Reasoning	390	2.6	No significant difference from overall score

Performance by content domains compared to previous cycle (2011) was found to be significantly lower in three content domains with the exception of Biology (See Table 4.5 below).

Table 4.5: *Performance by Science Content Domains Compared to Previous Cycle*

Cycle	Mean of Content domain			
	Biology(SE)	Chemistry(SE)	Physics(SE)	Earth Science(SE)
2015	397 (2.9)	390 (3.6)	384 (2.8)	368 (3.1)
2011	401(3.9)	403 (3.6)	417 (3.6)	384(4.3)
Difference between 2011 & 2015	-4	-13	-33	-16
2015 Diff from overall score (392)	5	-2	-8	-24

Further analysis revealed that Earth Science and Physics had the highest differences from the Science overall score of -24 and -8 respectively. It is worth noting that Botswana students dropped in performance in all science content domains, compared to the previous performance, with the highest differences in Physics and Earth Science of -33 and –16 respectively. Thus more attention should not only be given to topics that are problematic to the students, but also to the declining performance holistically.

Performance by school type

Both public schools and [1]private schools participated in the study. Private schools students constituted only 2.15% (619) of the sample (Table 4.6).

[1] Private schools refer exclusively to English Medium Schools

Table 4.6: *Composition by school type*

School type	n	%
Public	5345	97.85
Private	619	2.15

Performance by private schools was far much higher than that of public schools in both Mathematics (521.97) and Science (540.32) as shown in Figure 4.11 below. Performance by private schools was above the TIMSS scale centre point of 500, and only 57 points and 99 points below the top performing country in Science and Mathematics respectively.

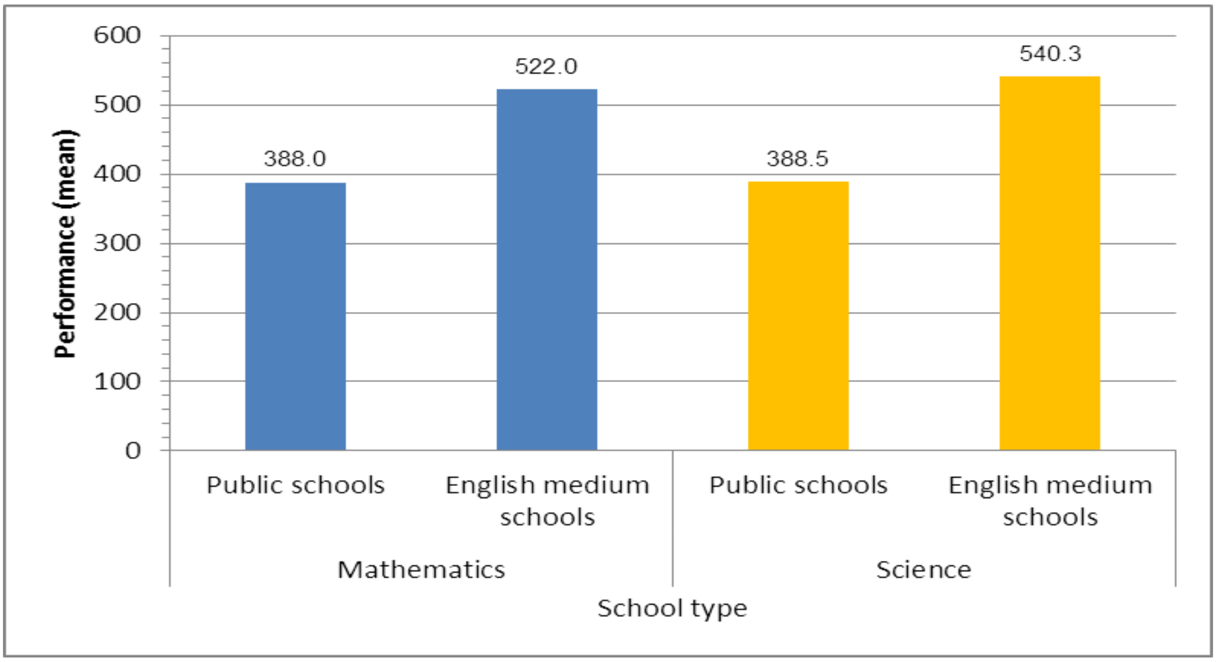


Figure 4.11: *Performance by School Type*

CHAPTER FIVE: PERFORMANCE BY REGIONS

There are 10 educational regions in Botswana. The Central region had the largest student population (36.40%) and Chobe constituted the least with 1.16%. Figure 5.1 shows performance by regions. The South East region performed the highest in both subjects, followed by the North East region. These two regions are the only ones with a mean performance above 400 as shown in Figure 5.1. It should be noted that the Kgalagadi region performed the least in both the subjects.

Table 5.1: *Composition and Performance by Region*

Region	n	%	Science			Mathematics		
			Mean	SE	SD	Mean	SE	SD
Central	1 977	36.40	384.96	4.17	105.55	385.57	3.66	81.52
Chobe	90	1.16	400.40	10.21	112.47	391.17	8.64	82.70
Ghanzi	110	2.17	379.59	16.71	109.77	384.61	15.57	76.97
kgalagadi	173	2.71	344.01	7.46	112.55	359.41	3.69	82.91
Kgatleng	312	5.01	395.48	5.45	97.25	393.65	2.93	73.15
Kweneng	857	13.06	377.40	5.01	104.73	379.52	3.87	79.99
North east	515	7.37	418.93	9.16	103.96	413.48	7.70	79.77
North west	408	7.19	385.68	11.46	108.93	385.80	8.20	82.23
South East	885	12.52	449.43	6.42	95.73	433.32	5.80	78.46
Southern	637	12.40	366.56	9.83	114.10	371.57	7.22	87.19

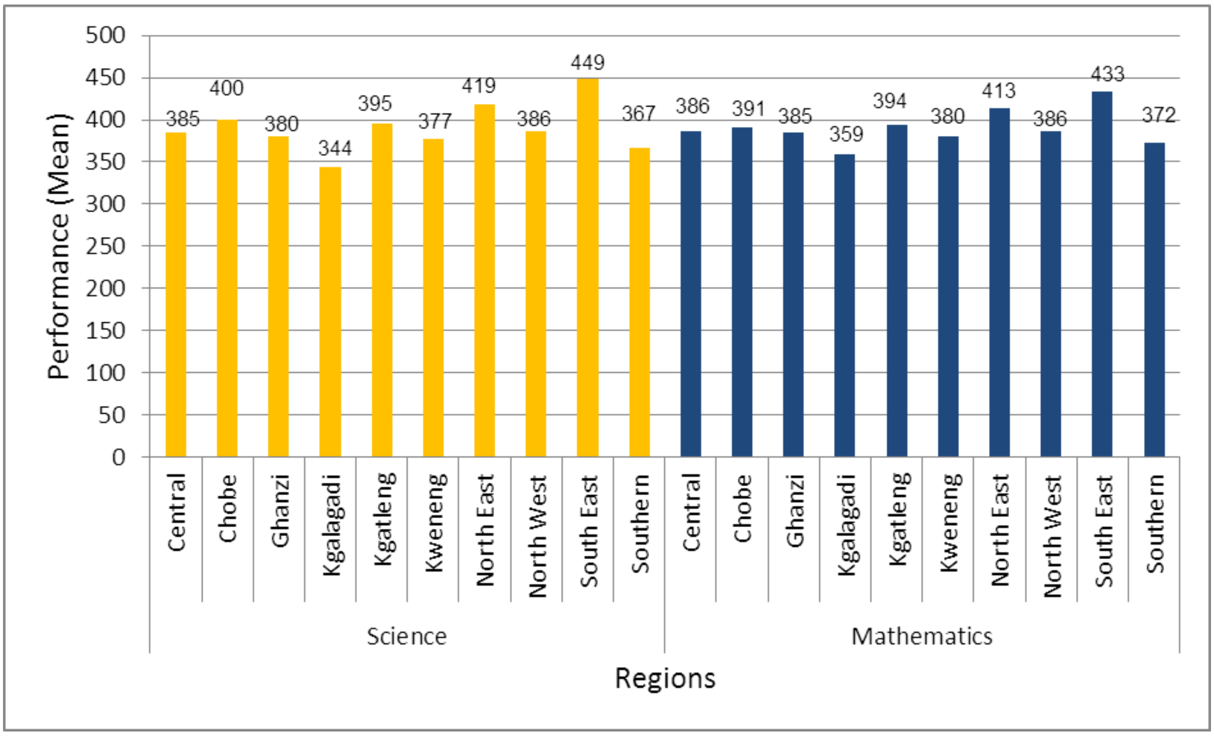


Figure 5.1: *Performance by Regions*

It must be noted that the South East and North East regions each encompass the only two cities in the country, hence they are likely to have more private schools, which perform better as seen in Table 5.1. For better comparisons of the regions, private schools were factored out. Six hundred and nineteen (619) students were identified to be coming from private schools and more than half (65%) of these students came from the South East District alone, followed by the North East and North West with 11% each (See Figure 5.2), while the Central region had the least of 2%. None came from Kgalagadi, Chobe and Gantsi regions.

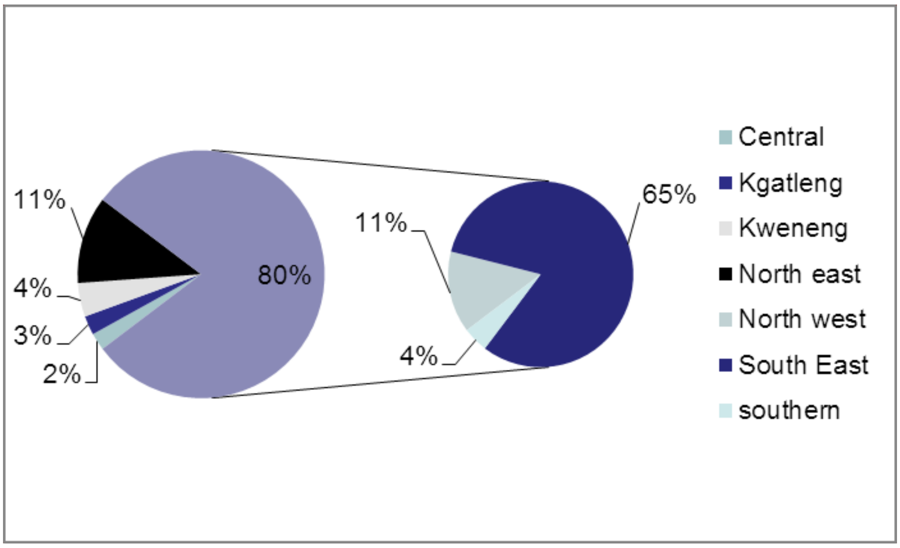


Figure 5.2: *Proportion of Private Schools by Region*

Despite that, the South East and North East still performed the highest in both subjects with an average score above 400 while the Kgalagadi region still performed the least in both subjects as shown in Figure 5.3. The high performance of both the South East and North East regions could be attributed to the regions' proximity to the resources found in the cities within them.

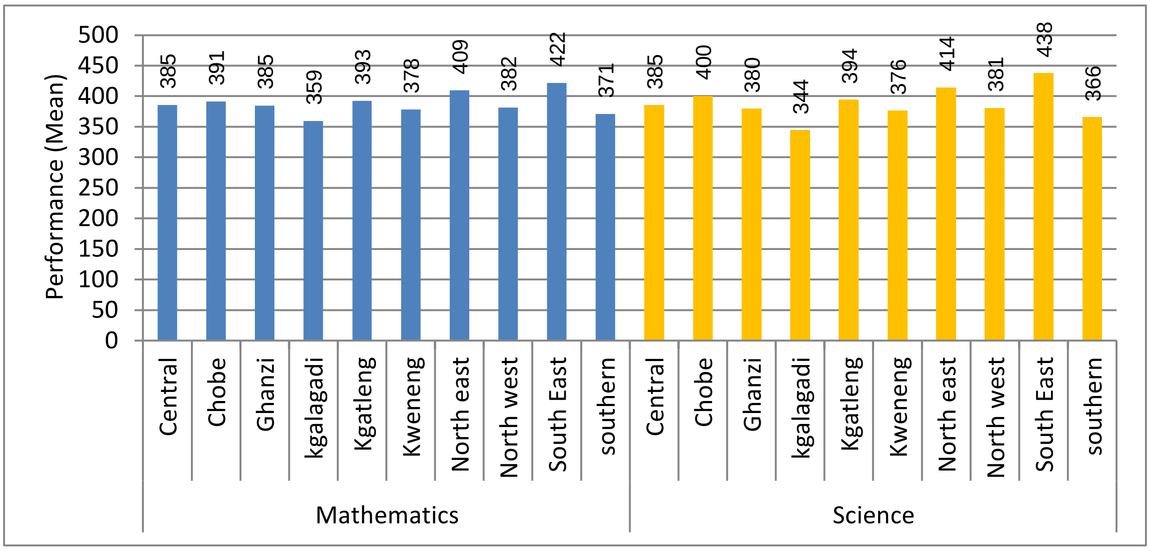


Figure 5.3: Public *Schools Performance by Region*

Contrary, all private schools scored above 480 in Mathematics and were almost at the TIMSS scale centre point of 500 in Science, with the Kweneng region performing the highest in Science while the North East performed the highest in Mathematics as shown in Table 5.2.

Table 5.2: *Private Schools' Performance by Regions*

Region	Mathematics			Science		
	Mean	SE	SD	Mean	SE	SD
Central	480.93	14.79	57.66	499.97	10.19	59.90
Kgatleng	491.45	12.48	59.25	504.39	18.86	68.71
Kweneng	528.32	5.74	47.46	550.90	5.59	59.88
North east	530.70	6.90	61.83	549.09	6.23	67.16
North west	508.30	8.87	63.24	525.16	11.39	70.29
South East	527.10	8.19	61.09	545.09	7.90	63.90
Southern	483.17	7.02	52.91	510.97	12.84	81.67

It should be noted that private schools performance was at least 100 points above public schools from the same region.

Regional Performance compared to Country performance

The mean score for each region in Mathematics and Science test is presented in Table 5.3 below. Four regions, namely the South East, North East, Kgatleng and Chobe, scored above the country mean in both Mathematics and Science. On the other hand, Kgalagadi, Southern and Kweneng regions scored far below the country mean, hence contributed significantly in the country's low mean score. The latter would need more assistance either in terms of resource allocation or system support.

Table 5.3: *Regional Mathematics and Science Achievement Differences from Overall National Achievement*

Region	n	%	Mathematics Region Mean	Mathematics SE	Mathematics Difference from National Mean	Science Region Mean	Science SE	Science Difference from National Mean
Central	1 977	36.40	385.57	3.66	5.27	384.96	4.17	6.84
Chobe	90	1.16	391.17	8.64	-0.33	400.40	10.21	-8.60
Ghanzi	110	2.17	384.61	15.57	6.23	379.59	16.71	12.21
Kgalagadi	173	2.71	359.41	3.69	31.43	344.01	7.46	47.79
Kgatleng	312	5.01	393.65	2.93	-2.81	395.48	5.45	-3.68
Kweneng	857	13.06	379.52	3.87	11.32	377.40	5.01	14.40
North east	515	7.37	413.48	7.70	-22.64	418.93	9.16	-27.13
North west	408	7.19	385.80	8.20	5.04	385.68	11.46	6.12
South East	885	12.52	433.32	5.80	-42.48	449.43	6.42	-57.63
Southern	637	12.40	371.57	7.22	19.27	366.56	9.83	25.24

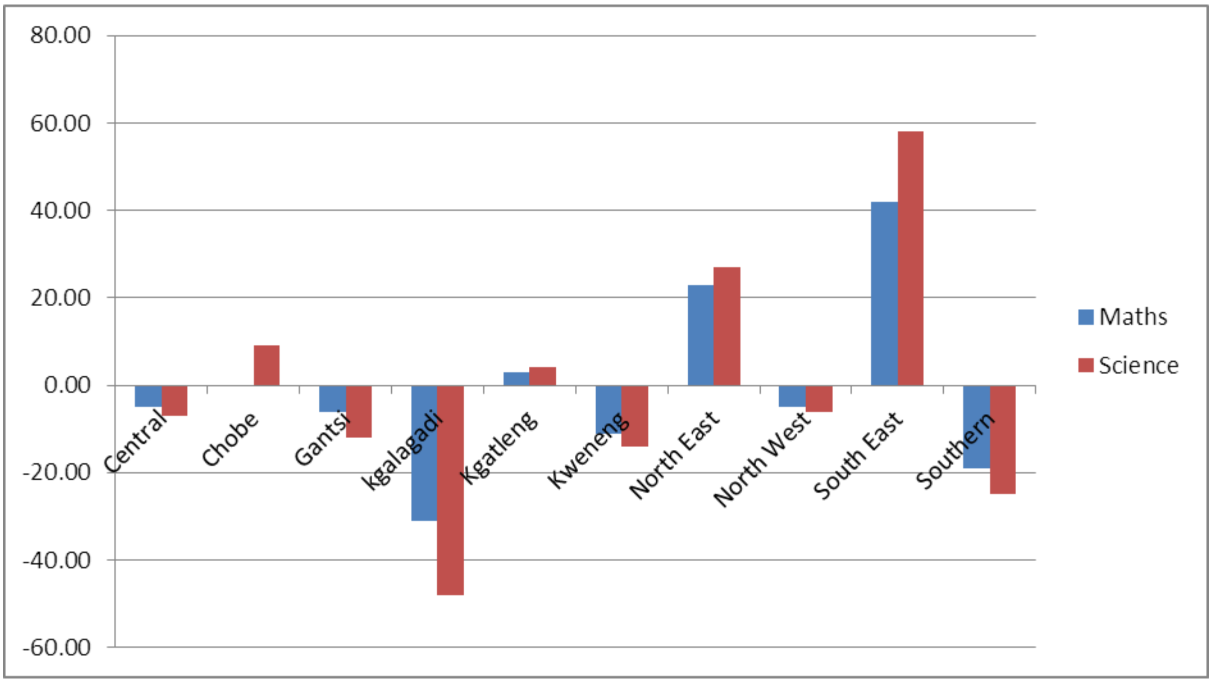
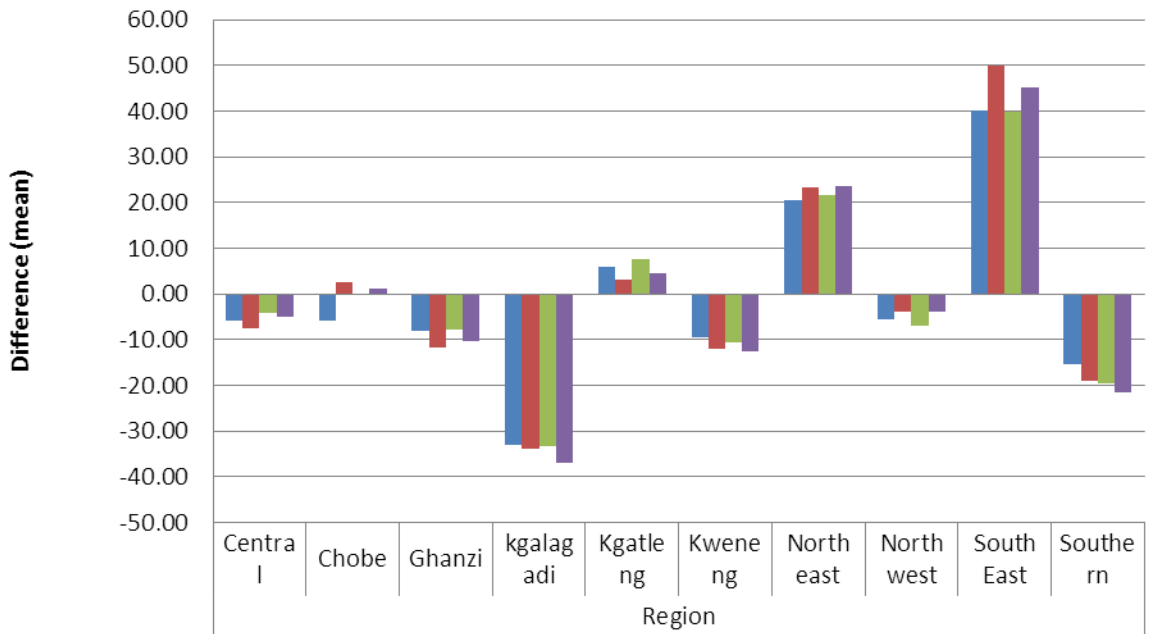


Figure 5.4: *Regional Performance Compared to Country Performance in Mathematics and Science.*

Regions' Difference from the Country Content Domain mean

Regions' performance in each content domain was compared with the national content domain to determine the problematic content domain for each region.

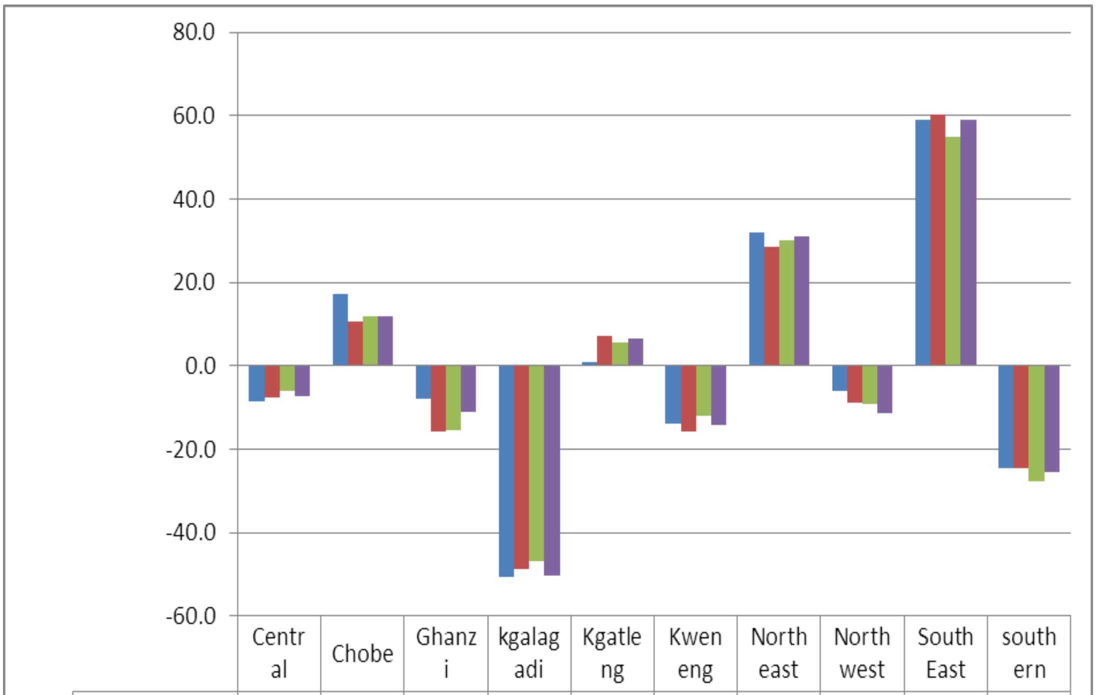
Figure 5.5 shows that South East, North East and Kgatleng performed above the national mean in all Mathematics content domains, with South East performing at least 40 points above the country mean in all content domains. Chobe's performance was almost the same as the national performance, except in Algebra which was below the country mean score. The rest of the regions performed below the country mean in all content domains, with Kgalagadi performing at least 30 points below the country mean scores in all content domains. Schools in regions performing below the country mean score need a lot of support from both regional and national level.



Region	Centra l	Chobe	Ghanzi	kgalag adi	Kgatle ng	Kwene ng	North east	North west	South East	Southe rn
Algebra	-5.84	-5.77	-8.07	-33.01	6.02	-9.55	20.41	-5.49	40.13	-15.48
Data & Chance	-7.62	2.65	-11.76	-33.78	3.16	-11.99	23.24	-3.86	49.87	-19.05
Geometry	-4.25	-0.12	-7.77	-33.39	7.49	-10.62	21.58	-7.05	39.81	-19.65
Number	-5.03	1.27	-10.30	-36.93	4.55	-12.47	23.62	-3.92	45.23	-21.65

Figure 5.5: *Mathematics Differences by Regions from Country Content Domain Means*

Likewise, an analysis was conducted to determine which Science content domain was problematic for each region. Figure 5.6 shows that the South East, North East, Kgatleng and Chobe regions performed above the national mean in all Science content domains, with South East performing at least 54 points above the country mean in all content domains. All other regions performed below the country mean in all content domains, with Kgalagadi performing at least 47 points below the country mean in all content domains. Schools in regions performing below the country mean score need a lot of support from both regional and national level.



	Central	Chobe	Ghanzi	kgalagadi	Kgatleng	Kweneng	North east	North west	South East	southern
Biology	-8.6	17.3	-8.1	-50.7	0.8	-14.0	32.1	-6.2	59.0	-24.5
Earth Science	-7.5	10.6	-15.8	-48.6	7.2	-15.6	28.5	-8.8	60.2	-24.7
Chemistry	-6.2	11.9	-15.4	-47.0	5.7	-12.0	30.2	-9.2	54.8	-27.7
Physics	-7.4	12.0	-11.1	-50.3	6.6	-14.2	31.0	-11.3	59.0	-25.6

Figure 5.6: *Regional Performance Difference by Science Content Domains*

CHAPTER SIX: ITEM LEVEL ANALYSIS

Item analysis investigates the performance of items considered individually either in relation to some external criterion or to the remaining items on a test. Normally two principal measures used in item analysis are item difficulty and item discrimination. Item difficulty is the percentage of the sample taking the test that answers that question correctly, while item discrimination is a measure of how well an item distinguishes between those with more skill from those with less skill. Item discrimination is measured by the discrimination index while item difficulty is measured by difficulty index. The focus in this chapter is on difficulty index. The higher the difficulty index, the easier the item, and vice versa.

(i) Mathematics Item level analysis

(a) Multiple Choice items

There were 115 Mathematics multiple choice items distributed almost equally by content domain. Algebra constituted the highest number of items (34), followed by Number (32), then Data and Chance (27) and the least Geometry (22). Each item was answered on average by 848 students, with a minimum of 835 and maximum of 860. As observed earlier, the overall percent correct for Mathematics was 23%. To understand the low performance on Mathematics, the percent correct (difficulty index or *p-value)* of each item was assessed. The % correct for Botswana students ranged from 6% to 78% with an average of 33%, an indication of poor performance overall. Table 6.1 shows the grouped percent correct and the number of items falling within each range.

Table 6.1: *p-value for Multiple Choice Items*

Percent Correct	Botswana		International Average		Commentary
	No. of items	Percent	No. of items	Percent	
0-10	2	1.7	0	0.0	Extremely difficult
11-20	19	16.5	2	1.7	Very Difficult
21-30	33	28.7	9	7.8	Difficult
31-40	24	20.9	19	16.5	Moderately Difficult
41-50	22	19.1	29	25.2	Moderately Easily
51-60	10	8.7	31	27.0	Easy
61-70	4	3.5	20	17.4	Very Easy
More than 70	1	.9	5	4.3	Extremely Easy
Total	115	100	115	100	

It is evident that two items were extremely difficult such that at most 10% got them correct. Internationally, items which 11-20% scored them correctly were only two, and none were scored correctly by at least 10%. Cumulatively, 21 items were answered correctly by 20% or less of Botswana students while internationally it was only two items. In other words, 21 items were very difficult to extremely difficult for Botswana students whereas only two items were to international students. This suggested that the test items were more difficult for Botswana students.

Items with a p-value ranging between .4 and .6 (or 40% and 60%) are acceptable in a test. If the p-value (% correct) is lower it means the item is difficult for most of the students and if on the other hand it is higher it means the item is very easy for most of the students. Thus 37 multiple choice items out of 115 were moderately easy to extremely easy for Botswana students (adding all the items for % correct range of ‘41 to more than 70’), compared to 85 items internationally. Effectively 78 items were considered difficult for Botswana students, compared to 30 items internationally. These difficult questions (with p-value of 0-30) were identified to be coming mostly from Algebra (22 items) followed by Geometry and Data and Chance with 13 items each, while Number had only 6 difficult items as shown in Table 6.2 below. It must be noted that the difficult items are from all levels of the cognitive domain. However, the two extremely difficult questions came from Geometry.

At a glance, the topic areas of each content domain which students had difficulties with are:
Number content domain:

- Fractions, decimals and integers
- Ratio, proportion and percent
- Whole numbers

Algebra content domain:

- Equations and inequalities
- Expressions and operations
- Relationships and functions

Geometry content domain:

- Geometric measurement
- Geometric shapes
- Location and movement

Data & Chance content domain:

- Chance
- Characteristics of data sets
- Data interpretation

Table 6.2: *Topic Areas that were Problematic to Students by Content and Cognitive Domain*

p-value	No. of items	Percent	Content domain	Topic Area and number of items ()	Cognitive domain	
0-10 (2)	2	1.7	Geometry	Geometric shapes x(2)	2 Reasoning	Extremely difficult
11-20 (19)	1	16.5	Number	• Fractions, decimals and integers x (1)	6 Knowing	
	7		Algebra	• Equations and inequalities (x2) • Expressions and operations (x3) • Relationships and functions (x2)	11 Application 2 Reasoning	Very Difficult
	4		Geometry	• Geometric measurement (x3) • Geometric shapes x (1)		
	7		Data & Chance	• Chance (x3) • Characteristics of data sets x (1) • Data interpretation (x3)		
21-30% (33)	5	28.7	Number	• Fractions, decimals and integers (x2) • Ratio, proportion and percent (x2) • Whole numbers x (1)	10 Knowing 18 Application 5 Reasoning	Difficult
	15		Algebra	• Equations and inequalities (x4) • Expressions and operations (x8) • Relationships and functions (x3)		
	7		Geometry	• Geometric measurement x (1) • Geometric shapes (x4) • Location and movement (x2)		
	6		Data & Chance	• Chance (x3) • Characteristics of data sets x (1) • Data interpretation (x2)		
Total	54	46.9		54	54	

Omitted multiple choice items

(i) Multiple choice

Despite the fact that multiple choice items involve guessing, students omitted some of the items for whatever reason. Table 6.3 shows the proportion of students omitting items by content domain and cognitive domain.

Table 6.3: *Proportion of Students Omitting Multiple Choice Items by Content and Cognitive Domains*

			No of items omitted from each content domain				No of items omitted from each cognitive domain		
% Omitting	No of items omitted	Percent	Number	Algebra	Geometry	Data & Chance	Knowing	Application	Reasoning
0	2	1.7	2	0	0	0	2	0	0
1	31	27.0	9	7	8	7	16	12	3
2	45	39.1	8	17	6	14	14	24	7
3	22	19.1	6	5	7	4	8	10	4
4	7	6.1	2	3	0	2	6	1	0
5	3	2.6	1	1	1	0	1	1	1
6	1	.9	0	1	0	0	0	1	0
7	1	.9	1	0	0	0	1	0	0
13	1	.9	1	0	0	0	1	0	0
14	1	.9	1	0	0	0	1	0	0
15	1	.9	1	0	0	0	1	0	0
[2]Total	115	100.0	32	34	22	27	51	49	15
(%)			(28)	(30)	(19)	(23)	(44)	(43)	(13)

The proportion of students omitting items ranged from 1% to 15%. Of the 115 multiple choice items, only two items were answered by all the students or not omitted by any student. These two items were both from Number content domain and of knowledge cognitive level. Thirty-one (31) items were omitted by 1%, while 45 items were omitted by 2% of the students and 22 items were omitted by 3% of the students. The majority (about 69%) of the forty-five (45) items that were omitted by 2% of the students; 90% of the omitted items by 1% and 82% came from Algebra and Data and Chance (Refer to Table 3.3 in Chapter 3 above for distribution of items by content domain and item format).

[2] This is the percentage omitted compared to the target percentage in each content and cognitive domain.

Six percent (6%) or more of the students omitted one question. Cross-tabulation of '*percent omitting'* with '*content domain'* reveals that all the items belonged to Number content domain, specific topic of *whole number,* except one item, as shown in Table 6.4. and all the items were at knowledge cognitive level. This indeed shows that this topic is difficult for the students, maybe because it was pitched at a high level or because teachers do not understand it or the way it is taught makes it difficult.

Table 6.4: *Content Domain from which Items were Mostly Omitted*

% of students omitting	No of items omitted	% of items omitted	Content Domain	Content domain	Item label	Cognitive domain
6	1	.9	Algebra	characteristics of data	Given point and slope, select collinear point	Application
7	1	.9	Number	Whole Number	T or F for n - addition	knowledge
13	1	.9	Number	Whole Number	T or F for n – subtraction	knowledge
14	1	.9	Number	Whole Number	T or F for n – multiplication	knowledge
15	1	.9	Number	Whole Number	T or F for n - division	knowledge

(ii) Structured Items

There were 97 structured items (See Table 3.3 above) and it is interesting to note that only one item was answered by all students and one question was not answered at all by up to 24% of the students. It is assumed that items that were not answered by the majority of the students were difficult hence it was interesting to find out the content domain, cognitive domain and topic area of such items as presented in Table 6.5.

Table 6.5: *Percentage of Students Omitting Structured Items by Content and Cognitive Domains and Topic Area*

% Omitting	No. of items	Percent	Content Domain	Cognitive Domain	Topic Area
10-20	10	10.0	Number	Application (x1)	Whole numbers
			Number	Reasoning (x1)	Whole numbers
			Algebra	Application (x1)	Expressions and operations
			Algebra	Reasoning (x1)	Relationships & functions
			Geometry	Application (x1)	Geometric measurement
			Geometry	Reasoning (x2)	Geometric Measurement
			Data & Chance	Reasoning (x3)	Characteristics of Data Sets
21-24	3	3.0	Geometry	Application (x1)	Geometric Shapes
			Number	Knowledge (x1)	Ratio, Proportion and Percent
			Data & Chance	Reasoning (x1)	Data Interpretation

Ten (10) items were not answered by 10-20% of the students while three (3) were not answered by 21-24% of the students and the majority of these items were of reasoning cognitive level. The content from which the items were omitted were as follows:

- Number: Whole Numbers; and Ratio, proportion and percent
- Algebra: Expressions and operations; and Relationships and functions
- Geometry: Geometric shapes; and Geometric measurement
- Data and Chance: Characteristics of data sets; and Data Interpretation

These topics proved to be problematic to the students. The content domain Number though relatively easy had some topics that were causing problems to the students such as Ratio, Proportion and Percent as students failed items at knowledge level. Although Number content domain is a relatively easy subject, whole numbers subtopic is a challenge to the students. For Algebra content domain, expressions and operations; and relationships and functions were problematic topics. For Geometry, geometric measurement and geometric shapes were the two most difficult topics for the students, while for Data and Chance, characteristics of data and data interpretation were the most difficult.

(iii) Science item level analysis

(a) Multiple choice items

It was reported that the percent correct for Science was 28%. Analysis was conducted to find out which items contributed to the low overall percent correct. Table 6.6 shows how students performed in each item, or put the other way, how difficult or easy the items were for the students. The smaller the percent correct the more difficult the item(s) was.

Table 6.6: *p-value for Multiple Choice Items*

% Correct	Botswana		International Average		Difficulty level of the items
	No of items	Percent	No of items	Percent	
0-10	1	.7	0	0.0	Extremely difficult
11-20	8	6.9	0	0.0	Very Difficult
21-30	25	20.7	2	1.4	Difficult
31-40	22	17.9	16	13.1	Moderately Difficult
41-50	25	20.7	33	27.6	Moderately Easily
51-60	22	17.9	24	20.0	Easy
61-70	13	11.0	22	17.9	Very Easy
More than 70	5	4.1	24	20.0	Extremely Easy
Total	121	100.0	121	100	

Botswana students found one item to be extremely difficult such that only less than 11% of the students got it correct, while on the contrary, they found five items to be extremely easy such that more than 70% of the students got them correct.

Comparison with the International students showed that there were no very difficult or extremely difficult items for international students as there was no item in which less than 20% of the students scored correct. Cumulatively, 34 items were answered correctly by 30% or less of Botswana students while internationally only two items were. This suggested that the TIMSS Multiple Choice Science items were more difficult for Botswana students than they were for international students.

Applying the golden rule for four-option multiple-choice-items of difficulty level of between .4 and .6, it turns out that 56 items out of 121 were out of range for Botswana students compared to 18 items internationally. Conversely, 65 multiple choice items out of 121 were moderately easy to extremely easy for Botswana students (adding all the items for % correct range of ‘’41 to more than 70’’), compared to 103 items for international students.

The difficult questions were identified to come from all the four content areas as shown in Table 6.7 below. Earth Science and Physics had 9 items each that were difficult, while biology and chemistry had 8 items each which students found to be difficult. Most of these items were of knowledge level (22 items) followed by application level (11) and reasoning level with the least items (7). However, the extremely difficult question came from the topic: *Earth in the Solar System and the Universe* of Earth Science content domain, implying that this is the most difficult topic in Science. Since the majority of the items (56%) were of knowledge level, including the most difficult item of the test, this shows that students did not grasp the basics that are fundamental for subsequent understanding of higher abstract content.

At a glance, the topic areas of each content domain which students had difficulties with are:

Earth Science:

- Earth in the Solar System and the Universe
- Earth's Structure and Physical Features
- Earth's Processes, Cycles, and History

Physics:

- Energy Transformation and Transfer
- Light and Sound;
- Electricity and Magnetism
- Forces and Motion
- Physical States and Changes in Matter

Biology:

- Cells and their Functions;
- Characteristics and Life Processes of Organisms
- Diversity, Adaptation, and Natural Selection;
- Ecosystems
- Life Cycles, Reproduction, and Heredity

Chemistry:

- Composition of Matter;
- Chemical Change
- Properties of Matter

Table 6.7: *Source of difficult items for Botswana students*

% Correct	Botswana		Item source			Difficulty level of the items
	No of items	Percent	Content	Topic area	Cognitive domain	
0-10.9	1	.7	Earth Science	• Earth in the Solar System and the Universe	knowledge	Extremely difficult
11-20.9	2	6.9	Physics	• Energy Transformation and Transfer • Light and Sound	4 Knowledge 2 Application 1 Reasoning	Very Difficult
	3		Biology	• Cells and Their Functions • Characteristics and Life Processes of Organisms • Diversity, Adaptation, and Natural Selection		
	2		Earth Science	• Earth's Processes, Cycles, and History • Earth's Structure and Physical Features		
	1		Chemistry	• Composition of Matter		
21-30.9	7	20.7	Physics	• Electricity and Magnetism • Forces and Motion • Light and Sound • Physical States and Changes in Matter	15 Knowledge 6 Applications 4 Reasoning	Difficult
	5		Biology	• Cells and Their Functions • Characteristics and Life Processes of Organisms • Diversity, Adaptation, and Natural Selection • Ecosystems • Life Cycles, Reproduction, and Heredity		
	6		Earth Science	• Earth's Structure and Physical Features • Earth in the Solar System and the Universe • Earth's Processes, Cycles, and History		
	7		Chemistry	• Chemical Change • Properties of Matter • Composition of Matter		

Percent Omitting

(i) Multiple Choice

Just like in Mathematics, some students did not attempt some questions. Table 6.8 presents the proportion of students omitting items.

Table 6.8: *Percentage of Students Omitting Items from each Content and Cognitive Domain*

% of students omitting items	No of items omitted	Percent	Content Domain				Cognitive Domain		
			Physics	Biology	Earth Science	Chemistry	Knowing	Application	Reasoning
1 - 5	87	71.7	22	28	21	15	47	30	10
5 - 10	5	4.1	0	1	2	3	2	3	0
10 - 15	10	8.3	0	2	4	4	4	6	0
15 - 20	9	7.6	1	0	4	4	7	2	0
21 - 25	2	1.4	2	0	0	0	2	0	0
25 - 30	5	4.1	3	0	0	2	0	5	0
30 - 35	3	2.8	1	0	0	2	0	3	0
[3]Total	121	100	29	31	31	30	62	49	10

The proportion of students omitting items ranged from 1% to 33%, but for purposes of reporting, these have been grouped as 1-5, 5-10, etc. Of the 121 multiple choice items, none of the items were answered by all the students. Eighty-seven items were omitted by 5% or less of the students. These items were the easy ones compared to three items which were omitted by at least 30% of the students. Thus the difficult items were omitted by a higher proportion of students and in this case any item omitted by at least 15% of the students was considered difficult.

It can be observed that students omitted almost the same number of items under each content domain. Likewise, students omitted more items of knowledge level followed by application and least of reasoning. Table 6.9 presents only the items considered to be difficult for the students (that is items omitted by at least 15% of students).

The specific topic areas these items came from were:

- Biology: Composition of Matter
- Physics: Light and Sound; and Electricity and Magnetism

[3] Percentage omitted compared to the target percentage in each content and cognitive domain.

- Earth Science: Earth Processes, Cycles and History; and Earth Structures and Physical Features

Table 6.9: *Source of Items Omitted by Students*

% of students omitting items	No of items omitted	Percent	Content Domain	Topic Area	Cognitive Domain
15 - 20	9	7.6	Physics Biology Earth Science	Light and sound Composition of matter Earth processes, cycles and history Earth structures and physical features	Knowledge Application
21 – 25	2	1.4	Physics	Light and sound	Knowledge
25 – 30	5	4.1	Physics Biology	Electricity and magnetism Composition of matter	Application
30 - 35	3	2.8	Physics Biology	Electricity and magnetism Composition of matter	Application

These difficult items came from knowledge level and application level. None belonged to reasoning cognitive domain. This goes to show that students lack basic knowledge of the subject matter.

Omitted Structured Items

Table 6.10 shows the proportion of students omitting structured items. The proportion of students omitting items ranged from 1% to 25%. Of the 113 structured items, none was answered by all the students.

Table 6.10: *Percentage of Students Omitting Items from each Content and Cognitive Domain*

Percent of students omitting	No of items omitted	Percent	Content domain				Cognitive Domain		
			Physics	Biology	Earth Science	Chemistry	Knowing	Application	Reasoning
0.0 - 5.0	55	48.7	22	15	5	13	28	10	17
5.1- 10.0	32	28.3	12	7	7	6	16	6	10
10.1 -15.0	14	12.4	8	0	3	3	5	4	5
15.1 - 20.0	8	7.1	2	1	3	2	3	1	4
20.1 - 25.0	4	3.5	0	2	1	1	2	0	2
Total	113	100.0	44	25	19	25	54	21	38

Fifty-five items were omitted by 5% or less of the students, while four items were omitted by more than 20% of the students. Most of the difficult questions (omitted by at least 15%) were spread across all content domains. Table 6.11 shows items omitted by high proportion of students.

Table 6.11: *Source of Most Difficult Items Omitted by the students*

Percent of students omitting	No of items omitted	Percent	Content domain	Topic area	Cognitive Domain
10 -15	14	12.4	Physics	• Light and sound	Knowledge x 4
			Biology	• Cells and their functions Characteristics and Life Processes of Organisms • Diversity, Adaptation, and Natural Selection • Ecosystem • Human Health • Life cycles, reproduction and heredity	Application x5 Reasoning x5
			Earth Science	• Earth processes, cycles and history	
			Chemistry	• Physical states and changes in matter	
15 - 20	8	7.1	Physics	• Electricity and magnetism • Forces and motions	Knowledge x1 Application x3
			Biology	• Cells and their functions	Reasoning x4
			Earth Science	• Earth in the Solar System and the Universe • Earth's resources, their uses and conservation • Earth's Structure and Physical Features	
			Chemistry	• Properties of Matter	
20 - 25	4	3.5	Biology	• Composition of matter	
			Earth Science	• Earth processes, cycles and history	Application x2 Reasoning x2
			Chemistry	• Physical states and changes in matter • Properties of Matter	
Total	26	23.0		26	26

Items that were omitted came from the following topic areas:

- Biology: Cells and their functions; Characteristics and Life Processes of Organisms; Diversity, Adaptation, and Natural Selection; Ecosystem; Human Health; Life Cycles, Reproduction and Heredity; Composition of Matter.
- Earth Science: Earth Processes, Cycles and History; Earth in the Solar System and the Universe; Earth's Resources, their uses and Conservation; Earth's Structure and Physical Features.
- Physics: Light and Sound; Electricity and Magnetism; Forces and Motions.

- Chemistry: Physical States and Changes in Matter; Properties of Matter; Physical States and Changes in Matter; Properties of Matter.

And most of the questions were of application and reasoning cognitive domains.

CHAPTER SEVEN: PERFORMANCE AT THE INTERNATIONAL BENCHMARKS

Introduction

TIMSS benchmarks describe student performance at various points along the TIMSS Mathematics and Science achievement scales. There are four points on the Mathematics and Science scales, namely: Advanced International Benchmark (625), High International Benchmark (550), Intermediate International Benchmark (475), and Low International Benchmark (400) (Gregory & Mullis, 1999; Mullis, Erberber, & Presuschoff, 2008). Table 7.1 delineates the content knowledge and conceptual understandings of what students scoring at each benchmark are likely to know and be able to do in Mathematics and Science (Mullis, Martin & Foy, 2008; Mullis & Foy, 2008).

Table 7.1: Abridged *Description of Mathematics and Science International Benchmarks*

Score	Mathematics	Science
625	Advanced International Benchmark	
	Students can apply and reason in a variety of problem situations, solve linear equations, and make generalizations.	Students communicate understanding of complex concepts related to Biology, Chemistry, Physics and Earth Science in practical, abstract, and experimental contexts.
550	High International Benchmark	
	Students can apply their understanding and knowledge in a variety of relatively complex situations.	Students apply and communicate understanding of concepts from Biology, Chemistry, Physics, and Earth Science in everyday and abstract situations.
475	Intermediate International Benchmark	
	Students can apply basic mathematical knowledge in a variety of situations.	Students demonstrate and apply their knowledge of Biology, Chemistry, Physics, and Earth Science in various contexts.
400	Low International Benchmark	
	Students have some knowledge of whole numbers and basic graphs.	Students show some basic knowledge of Biology, Chemistry, Physics, and Earth Science.

The percentage of students reaching each benchmark is presented in Figure 7.1. A very small percentage of students reached the ‘’Advanced Benchmark’’ in both Mathematics (0.10% compared to 5% internationally) and Science (0.44% compared to 7% internationally. The percentage reaching the successive benchmark is cumulative (that is, the next bar is inclusive of the previous bar). Thus, 47.4% of students reached the Low benchmark in Mathematics while 51.1% did in Science, compared to an international average of 84% in both Mathematics and Science.

Countries were able to educate 84% of their eighth grade students to a basic level of Mathematics and Science compared to Botswana's 47.4% and 51.1% respectively. This means that 52.6% and 48.9% of Botswana students in Mathematics and Science respectively lack basic knowledge in the subjects. The high proportion of students failing to reach the low international benchmark requires appropriate interventions to be put in place to enhance learning.

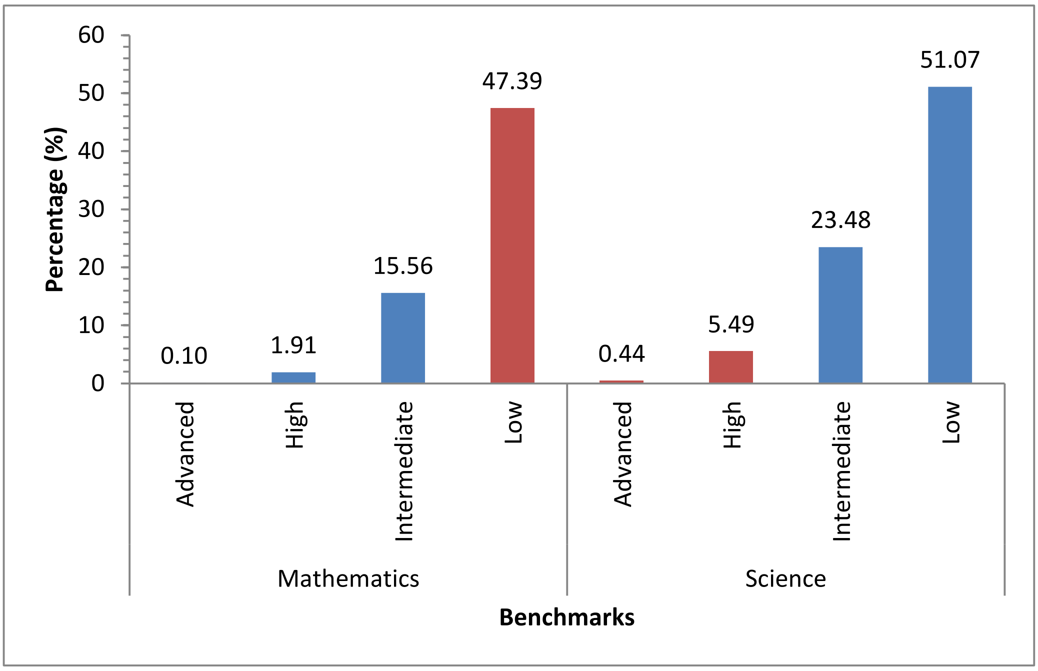


Figure 7.1: *Percentage of Students Reaching International Benchmarks for Botswana and Internationally*

It is important to note that the proportion of students reaching each international benchmark has dropped at each benchmark compared to the previous cycle (See Figure 7.1), with the exception of Mathematics at intermediate benchmark. In TIMSS 2011, the proportion of students reaching low international benchmark in Mathematics and Science was 55.0% and 50.0% respectively compared to 47.4% in Mathematics and 51.1% in Science, a sign of decline in the quality of education. The declining quality in education has been the concern of the government ever since the inception of The Revised National Policy on Education in 1994 (Government of Botswana, 1994). However, more than twenty years since the introduction of the policy the quality is still declining (Jaap, 2014).

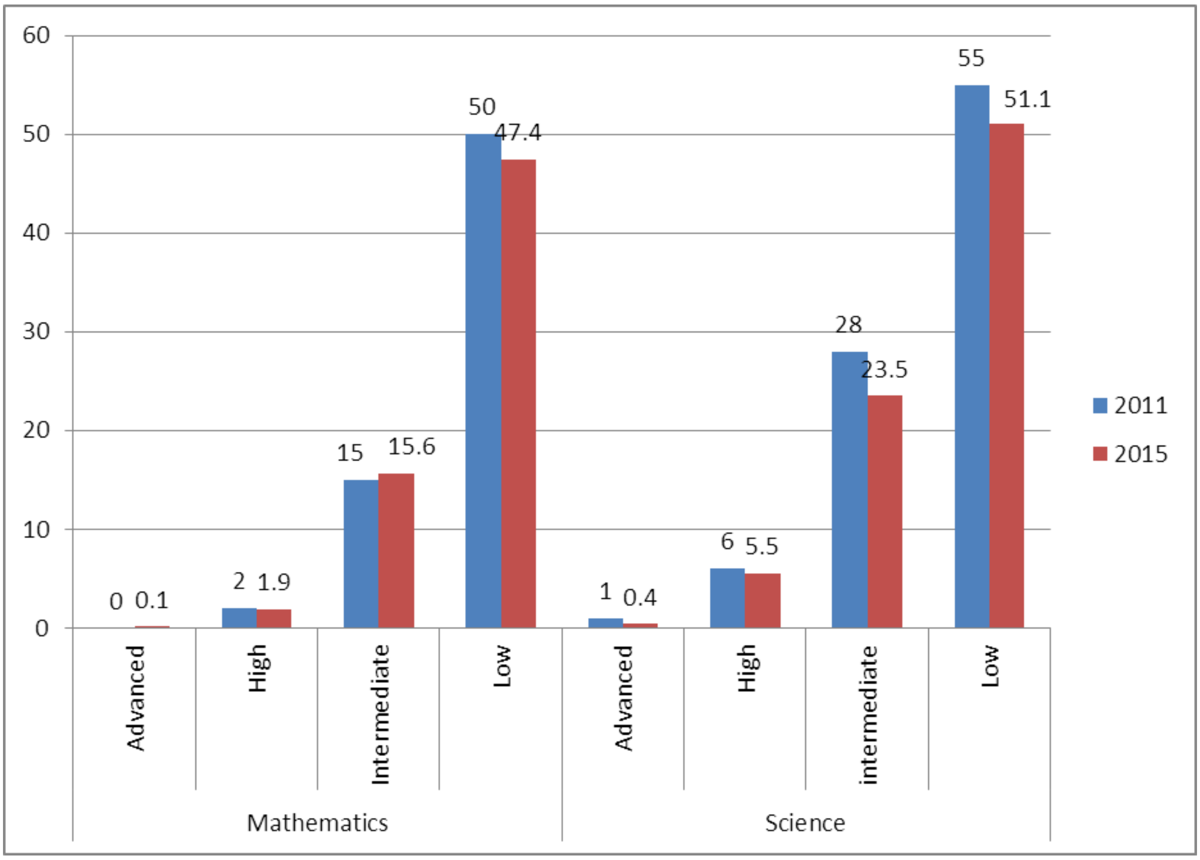
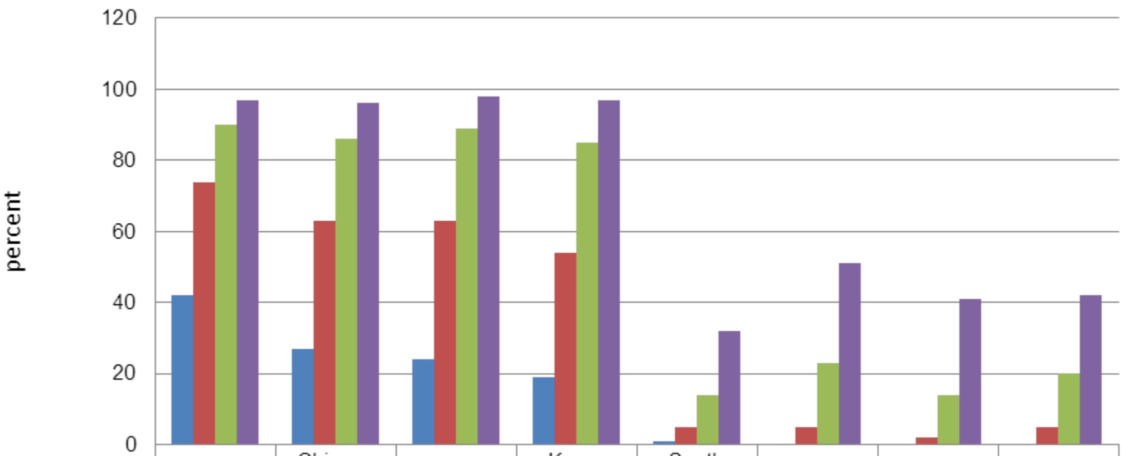


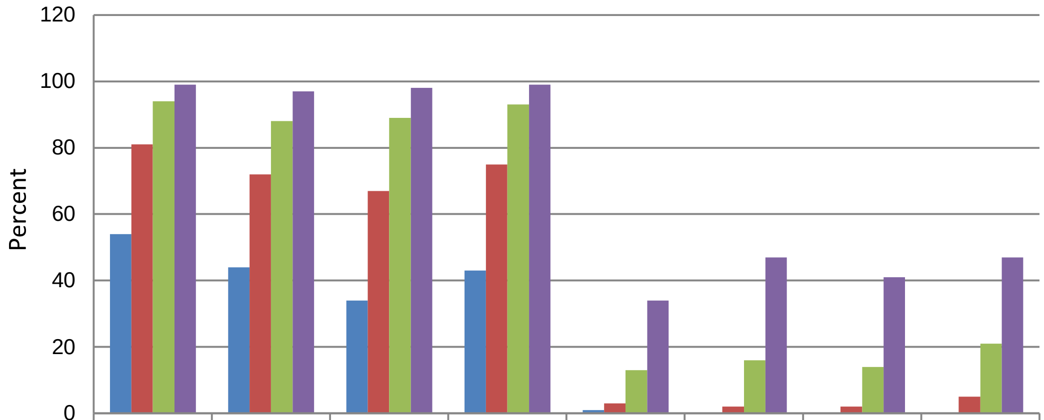
Figure 7.2*: Trend Performance at each International Benchmark*

Comparison between Botswana students and other countries reaching international benchmarks is presented in Figures 7.2 and 7.3. Top performing countries attained above 96% performance on low benchmarks in both Mathematics and Science. Of the four participating African countries, none attained more than 50% of low benchmarks, except Botswana in Science with 51% (Botswana and South Africa used Grade 9 students). It is interesting to note that while top performing countries were able to educate almost all of their students to a basic level, countries in the African continent are still challenged to do that. To some extent, this is understandable because all indicators point to African countries being underdeveloped or still developing while the European and most of the Asian countries are well developed.



	Singapore	Chinese Taipei	Japan	Korea Republic	South Africa	Botswana	Morocco	Egypt
Advanced	42	27	24	19	1	0	0	0
High	74	63	63	54	5	5	2	5
Intermediate	90	86	89	85	14	23	14	20
Low	97	96	98	97	32	51	41	42

Figure 7.3*: Botswana Students' Reaching International Benchmarks in Science Compared with other Participants*



	Singapre	Chinese Taipei	Japan	Korea Republic	South Africa	Botswana	Morocco	Egypt
Advanced	54	44	34	43	1	0	0	0
High	81	72	67	75	3	2	2	5
Intermediate	94	88	89	93	13	16	14	21
Low	99	97	98	99	34	47	41	47

Figure 7.4*: Botswana Students' Reaching International Benchmarks in Mathematics Compared with other Participants*

Performance at Benchmarks by School Type

Comparison of performance at benchmarks shows that private schools outperformed public schools as shown in Figure 7.5. Of the 619 private school students, 4.1% (24) reached advanced benchmarks compared to 1 out of 5345 (0.02%) students in public schools. Only

3.1% (22) of students from private schools did not reach the Low benchmark compared to 53.7% (2914) students from public schools.

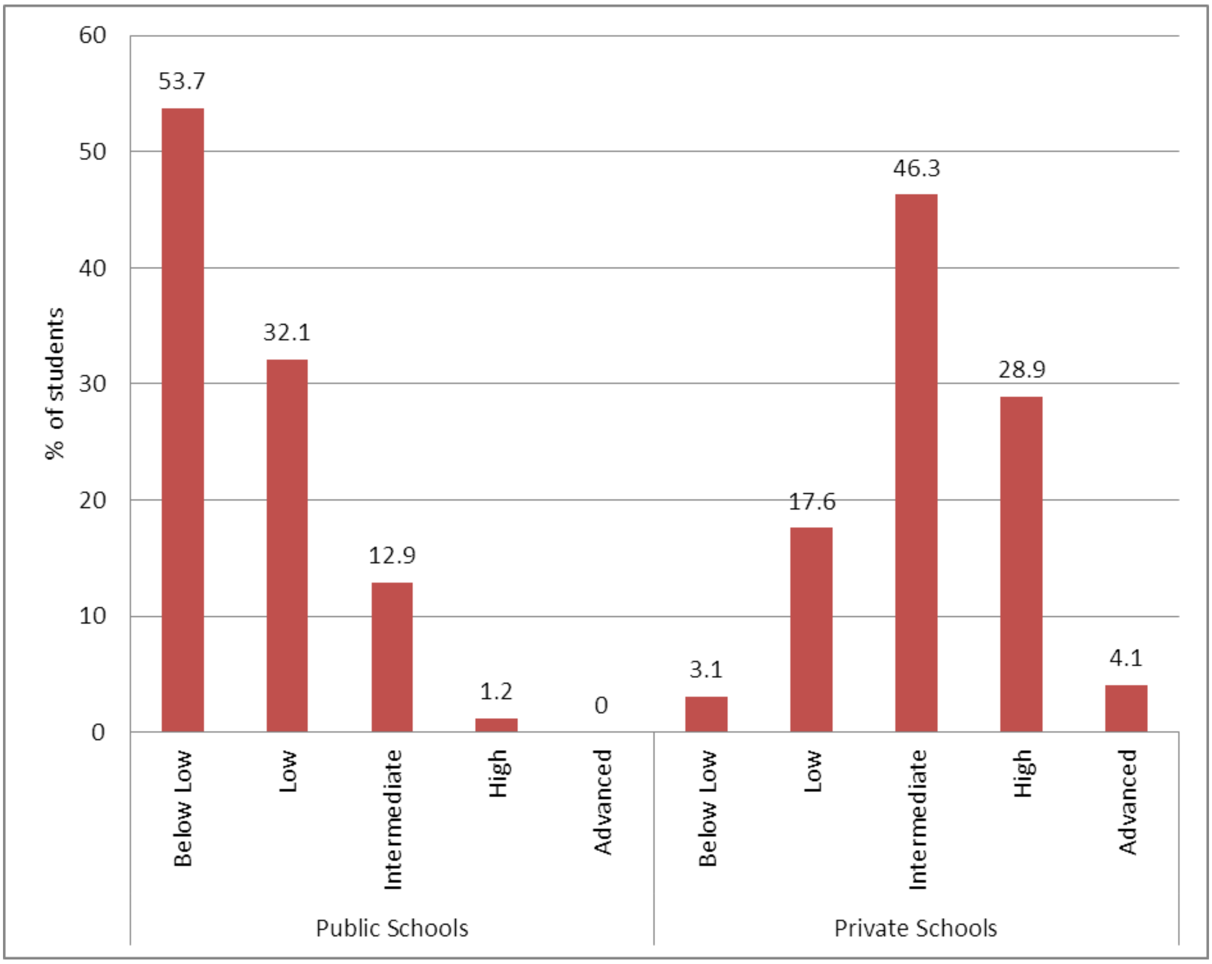


Figure 7.5: *Proportion of Students in Public and Private Schools Reaching each International Benchmark*

This means that more than half of the students in public schools require serious remedial interventions to enable them to perform up to at least low benchmark. Thus a lot of resources are required; physical, time and human to assist such students.

Performance at Benchmarks by Regions

To further help regions to zero in on the issues facing them and device appropriate strategies to help improve their delivery, analysis was done by region for each subject. Description of each benchmark is given in Chapter Two above. Performance at each benchmark by region is presented in Table 7.2.

Table 7. 2: *Proportion of Students Reaching each Benchmark by Region*

Region	Benchmark	Science		Mathematics	
		N	%	n	%
Central	Below 400	999	51.43	1 068	55.02
	400 to 474	530	27.40	612	31.32
	475 to 549	338	17.20	240	12.38
	550 to 624	70	3.73	23	1.26
	625 Or Above	5	0.24	0	0.02
Gantsi	Below 400	64	51.84	67	54.48
	400 to 474	27	27.47	33	33.55
	475 to 549	16	17.96	10	11.70
	550 to 624	2	2.72	0	0.27
	625 Or Above	0	0.00	0	0.00
Kgalagadi	Below 400	115	67.59	117	68.19
	400 to 474	35	19.40	42	23.78
	475 to 549	17	9.87	12	7.30
	550 to 624	5	2.92	1	0.73
	625 Or Above	0	0.21	0	0.00
Kgatleng	Below 400	139	47.88	141	48.39
	400 to 474	100	32.30	125	40.14
	475 to 549	57	16.36	41	10.88
	550 to 624	15	3.29	5	0.60
	625 Or Above	1	0.16	0	0.00
Kweneng	Below 400	459	55.43	487	59.03
	400 to 474	225	26.93	242	28.92
	475 to 549	127	13.96	113	11.34
	550 to 624	42	3.57	13	0.67
	625 Or Above	5	0.11	2	0.04
North East	Below 400	185	39.34	201	42.79
	400 to 474	147	29.61	180	35.51
	475 to 549	138	23.09	123	19.00
	550 to 624	65	7.12	40	2.49
	625 Or Above	14	0.83	5	0.20
North West	Below 400	218	49.92	239	54.72
	400 to 474	132	28.07	147	32.01
	475 to 549	96	16.94	84	11.61
	550 to 624	46	4.52	26	1.60
	625 Or Above	7	0.55	2	0.06
South East	Below 400	187	27.44	226	33.67
	400 to 474	218	30.29	269	36.00
	475 to 549	269	28.06	250	23.61
	550 to 624	178	12.71	125	6.20
	625 Or Above	33	1.50	15	0.52
Southern	Below 400	372	57.76	388	60.80
	400 to 474	149	24.49	173	27.80
	475 to 549	88	14.25	68	10.48
	550 to 624	26	3.31	8	0.91
	625 Or Above	3	0.20	0	0.00

At least 50% of students in Central, Gantsi, Kweneng, Southern, Northwest and Kgalagadi districts failed to reach the Low benchmark in both Mathematics and Science. On the other hand South East had the lowest proportion of students in both Mathematics (34%) and

Science (27%) who failed to reach the Low benchmark, suggesting that students in this region did comparatively well. The regions with more than 50% of their students failing to reach the low benchmark should be given more support to help them improve learning and hence performance.

Exemplar Items at International Benchmarks

Sample items representative of different international benchmarks are illustrated below for readers to appreciate how Botswana students performed at each benchmark relative to other countries and the international average. The selected four items from each benchmark provide some evidence of whether students have mastered the content at that level (Mullis, Martin, Foy, and Hooper, 2016; Martin, Mullis, Foy, and Hooper, 2016).

Exemplar items at Low international benchmark (400)

Figure 7.6 below is a 1-point Mathematics structured item from Data and Chance content domain of application level of the cognitive domain. Hong Kong SAR scored the highest with 85%, and Jordan scored the least with 42%. Botswana scored 44% far much lower than the International average of 64%. Thus only 44% of Botswana students got the item correct compared to 85% of Hong Kong SAR and 64% internationally. This item was too difficult for Botswana students despite the fact that it was at low international benchmark.

TIMSS 2015 Mathematics 8th Grade

Exhibit 2.11.1: Low International Benchmark – Example Item 1

Country	Percent Full Credit	
Hong Kong SAR	85 (1.4)	▲
[2] Singapore	83 (1.2)	▲
Slovenia	81 (1.7)	▲
[2] Lithuania	81 (2.1)	▲
Japan	79 (1.9)	▲
Malta	76 (1.9)	▲
Chinese Taipei	76 (1.8)	▲
Australia	74 (1.4)	▲
Korea, Rep. of	71 (2.2)	▲
Hungary	70 (2.0)	▲
Russian Federation	70 (2.6)	▲
Norway (9)	69 (2.3)	▲
Lebanon	69 (2.2)	▲
Bahrain	67 (1.9)	
United Arab Emirates	67 (1.1)	▲
† United States	64 (1.4)	
Kazakhstan	64 (2.1)	
[3] Israel	64 (1.8)	
Thailand	64 (2.1)	
International Avg.	64 (0.3)	
Malaysia	63 (2.0)	
Turkey	62 (1.9)	
Qatar	62 (1.9)	
Morocco	61 (1.2)	
Oman	61 (2.2)	
[2] Italy	60 (2.3)	
[1] † Canada	59 (1.5)	▼
Kuwait	59 (2.8)	
England	58 (2.1)	▼
Sweden	57 (2.6)	▼
Chile	56 (2.2)	▼
Iran, Islamic Rep. of	56 (1.4)	▼
Egypt	53 (1.9)	▼
Ireland	53 (2.2)	▼
South Africa (9)	52 (1.7)	▼
[1 2] Georgia	52 (2.6)	▼
† New Zealand	51 (1.8)	▼
Saudi Arabia	49 (2.5)	▼
Botswana (9)	44 (2.2)	▼
Jordan	42 (1.9)	▼

Content Domain: Data and Chance

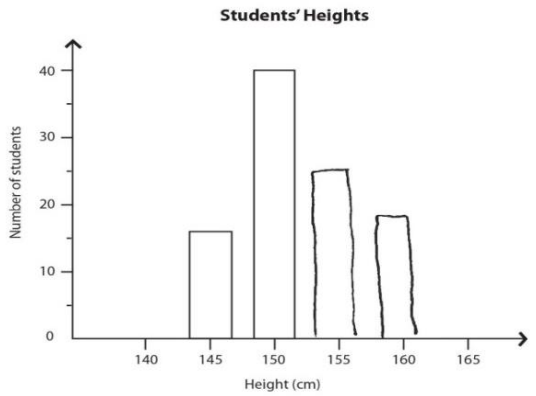
Cognitive Domain: Applying

Description: Uses information in a table to complete a bar graph

The heights of 100 students in a school were measured to the nearest 5 cm.
This table shows the results.

Height (cm)	145	150	155	160
Number	16	40	25	19

Complete this bar chart to show the same information.



The answer shown illustrates the type of response that would receive full credit (1 point).

Country	Percent Full Credit
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.6: *Mathematics Low International Benchmark Item*

Figure 7.7 is another example of a Mathematics low international benchmark multiple choice item from Data and Chance content domain of knowledge level of the cognitive domain. Singapore scored the highest with 96% and Egypt scored the least with 55%. Botswana scored 59% far much lower than the International average of 78%. Thus only 59% of Botswana students got the item correct compared to 96% of Singapore and 78% internationally. This item was too difficult for Botswana students despite the fact that it was at low international benchmark.

TIMSS 2015 Mathematics 8th Grade

Exhibit 2.11.2: Low International Benchmark – Example Item 2

Country	Percent Correct	
[2] Singapore	96 (0.6)	▲
Hong Kong SAR	95 (0.9)	▲
Korea, Rep. of	95 (0.9)	▲
Chinese Taipei	95 (0.9)	▲
Japan	93 (1.1)	▲
England	92 (1.2)	▲
Slovenia	90 (1.4)	▲
Ireland	90 (1.2)	▲
[2] Lithuania	89 (1.5)	▲
Australia	87 (1.3)	▲
Hungary	86 (1.7)	▲
[1 †] Canada	86 (1.3)	▲
[†] New Zealand	85 (1.4)	▲
[2] Italy	85 (1.7)	▲
[†] United States	84 (1.0)	▲
Norway (9)	84 (1.8)	▲
Russian Federation	84 (1.8)	▲
Malta	83 (1.5)	▲
[1 2] Georgia	81 (2.1)	
Thailand	81 (1.9)	
United Arab Emirates	79 (0.9)	
[3] Israel	78 (1.5)	
International Avg.	78 (0.3)	
Sweden	78 (1.8)	
Bahrain	75 (1.9)	
Malaysia	75 (1.6)	
Turkey	75 (2.4)	
Kazakhstan	73 (2.0)	▼
Iran, Islamic Rep. of	70 (1.8)	▼
Chile	70 (1.9)	▼
Qatar	69 (1.8)	▼
Kuwait	66 (2.1)	▼
Lebanon	64 (2.6)	▼
Oman	61 (1.5)	▼
Morocco	60 (1.5)	▼
Botswana (9)	59 (1.6)	▼
Jordan	58 (1.9)	▼
South Africa (9)	57 (1.7)	▼
Saudi Arabia	56 (2.6)	▼
Egypt	55 (1.9)	▼

Content Domain: Data and Chance

Cognitive Domain: Knowing

Description: Identifies the table that matches the information shown in a pictograph

The pictogram shows how many pizzas a shop sold in four months.

One of these tables shows the same information, which one?

Ⓐ

Month	Pizzas Sold
January	60
February	80
March	60
April	60

● (B)

Month	Pizzas Sold
January	70
February	80
March	60
April	70

Ⓒ

Month	Pizzas Sold
January	70
February	140
March	60
April	70

Ⓓ

Month	Pizzas Sold
January	60
February	80
March	70
April	60

Country	Percent Correct
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.7: *Mathematics Low International Benchmark Item*

Figure 7.8 is an example of a Science low international benchmark multiple choice item from Earth Science content domain at application level of the cognitive domain. Hungary scored the highest with 95% and South Africa with 48% as the lowest. Botswana scored 56% far much lower than the International average of 80%. Thus only 56% of Botswana students got the item correct compared to 95% of Hungary and 80% internationally. This was a relatively easy item judging by the international high percent correct, yet it was too difficult for Botswana students despite the fact that it was at low international benchmark.

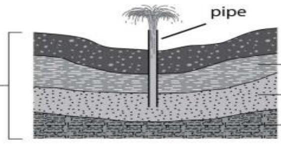
TIMSS 2015 Science 8th Grade

Exhibit 2.11.2: Low International Benchmark – Example Item 2

Country	Percent Correct
Hungary	95 (1.0)
Kazakhstan	92 (1.1)
Russian Federation	91 (1.4)
England	91 (1.3)
Chinese Taipei	91 (1.1)
2 Lithuania	91 (1.5)
2 Singapore	91 (1.0)
Slovenia	90 (1.4)
Ireland	90 (1.3)
† United States	90 (0.9)
1 † Canada	89 (1.0)
2 Italy	88 (1.6)
Australia	88 (1.0)
Thailand	86 (1.3)
Sweden	85 (1.7)
1 2 Georgia	85 (1.8)
Japan	85 (1.5)
Korea, Rep. of	84 (1.3)
Norway (9)	83 (1.7)
Malta	83 (1.9)
† New Zealand	82 (1.6)
Turkey	82 (1.5)
Chile	81 (1.8)
3 Israel	80 (1.5)
United Arab Emirates	80 (1.1)
International Avg.	80 (0.3)
Oman	79 (1.4)
Hong Kong SAR	78 (2.3)
Jordan	78 (1.4)
Iran, Islamic Rep. of	76 (1.6)
Bahrain	75 (2.0)
Qatar	73 (1.9)
Malaysia	69 (2.0)
Kuwait	69 (2.3)
Saudi Arabia	65 (2.2)
Morocco	63 (1.3)
Egypt	60 (2.2)
Botswana (9)	56 (2.0)
Lebanon	54 (2.8)
South Africa (9)	48 (2.2)

Content Domain: Earth Science
Cognitive Domain: Applying
Description: Using a diagram, identifies what moves water from an artesian basin to the surface

An artesian basin holds water underground in a layer of rock. Part of an artesian basin is shown in the diagram.



When people put pipes down into the rock layer, water rises up the pipe and runs onto the ground.

What moves the water up the pipe?

- (A) electricity
- (B) magnetism
- ● pressure
- (D) gravity

Country	Percent Correct
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.8: *Science Low International Benchmark Item*

Figure 7.9 is another example of a Science low international benchmark multiple choice item from Chemistry content domain of knowledge level of the cognitive domain. Chinese Taipei scored the highest with 95%, and South Africa scored the least with 63%. Botswana scored 74% lower than the International average of 81%. Thus 74% of Botswana students got the item correct compared to 95% of Chinese Taipei and 81% internationally. This was a relatively easy item judging by the international high percent correct. Thus the item was relatively difficult for Botswana students despite the fact that it was at low international benchmark.

TIMSS 2015 Science 8th Grade

hibit 2.11.1: Low International Benchmark – Example Item 1

Content Domain: Chemistry
Cognitive Domain: Knowing
Description: Recognizes a material that best conducts both heat and electricity

Which of the following is the best conductor of both heat and electricity?

Ⓐ wood
Ⓑ plastic
● copper
Ⓓ glass

Country	Percent Correct	
Chinese Taipei	95 (0.8)	▲
[2] Singapore	94 (0.8)	▲
Thailand	93 (1.1)	▲
Korea, Rep. of	92 (1.0)	▲
Hong Kong SAR	92 (1.2)	▲
[3] Israel	90 (1.1)	▲
Malaysia	88 (1.2)	▲
Sweden	88 (1.6)	▲
Norway (9)	86 (1.4)	▲
Japan	86 (1.3)	▲
Jordan	86 (1.5)	▲
Russian Federation	84 (1.6)	▲
Egypt	84 (1.3)	▲
Turkey	84 (1.5)	▲
Iran, Islamic Rep. of	83 (1.5)	
Oman	83 (1.4)	
England	82 (1.5)	
Slovenia	82 (1.8)	
Bahrain	82 (1.8)	
Morocco	81 (1.0)	
United Arab Emirates	81 (0.9)	
Kazakhstan	81 (1.9)	
International Avg.	81 (0.3)	
Kuwait	80 (2.0)	
Hungary	80 (1.9)	
Qatar	79 (1.7)	
[1] United States	79 (1.1)	
[2] Italy	78 (2.0)	
Ireland	78 (1.7)	
Australia	77 (1.7)	▼
Chile	75 (1.9)	▼
Malta	75 (1.8)	▼
Saudi Arabia	74 (2.3)	▼
Botswana (9)	74 (1.7)	▼
[1] New Zealand	73 (1.8)	▼
[1] Canada	70 (1.6)	▼
[2] Lithuania	69 (2.4)	▼
Lebanon	64 (2.7)	▼
South Africa (9)	63 (1.5)	▼

Country	Percent Correct

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.9: *Science Low International Benchmark Item*

In summary, Botswana performed below the international average in all the four items presented above, suggesting that the items were above the cognitive level of Botswana students.

Exemplar items at the TIMSS 2015 Intermediate International Benchmarks (475)

Figure 7.10 presents an example of a Mathematics intermediate international benchmark multiple choice item from Data and Chance content domain at knowledge level of the cognitive domain. Republic of Korea scored the highest with 83%, and Morocco scored the least with 39%. Botswana scored 54% below the International average of 62%. Thus 54% of Botswana students got the item correct compared to 83% of Republic of Korea and 62% internationally. Thus the item was relatively difficult for Botswana students.

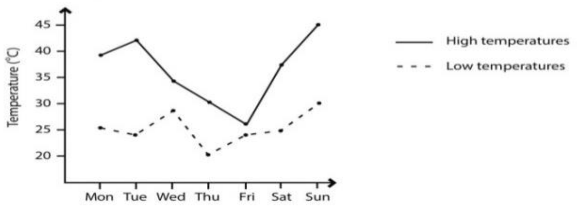
TIMSS 2015 Mathematics 8th Grade

Exhibit 2.12.5: Intermediate International Benchmark – Example Item 5

Country	Percent Correct	
Korea, Rep. of	83 (1.5)	▲
Japan	83 (1.3)	▲
Chinese Taipei	80 (1.5)	▲
[2] Singapore	80 (1.4)	▲
Hong Kong SAR	78 (2.0)	▲
[2] Italy	73 (2.2)	▲
Russian Federation	72 (2.9)	▲
England	70 (2.0)	▲
[1] † Canada	70 (1.8)	▲
Ireland	68 (2.3)	▲
[2] Lithuania	67 (2.2)	▲
Turkey	66 (1.8)	▲
† New Zealand	66 (1.5)	▲
Thailand	65 (2.1)	
Hungary	65 (2.1)	
Malaysia	65 (1.8)	
Kazakhstan	64 (3.1)	
† United States	64 (1.7)	
Norway (9)	64 (2.2)	
Australia	63 (1.5)	
[3] Israel	62 (1.6)	
Chile	62 (2.0)	
International Avg.	62 (0.3)	
United Arab Emirates	61 (1.1)	
Slovenia	60 (2.1)	
Sweden	60 (2.6)	
Malta	56 (2.3)	▼
Qatar	55 (2.5)	▼
Oman	54 (1.7)	▼
Lebanon	54 (2.7)	▼
[1] [2] Georgia	54 (2.8)	▼
Botswana (9)	54 (1.8)	▼
South Africa (9)	52 (1.4)	▼
Bahrain	51 (2.4)	▼
Kuwait	50 (2.3)	▼
Iran, Islamic Rep. of	48 (2.2)	▼
Saudi Arabia	46 (2.5)	▼
Jordan	46 (1.9)	▼
Egypt	42 (1.9)	▼
Morocco	39 (1.7)	▼

Content Domain: Data and Chance
Cognitive Domain: Knowing
Description: Reads values from two line graphs to solve a problem

Temperature Chart of a Week in Zedland



The graph above shows the daily high and low temperatures for a week at a place in Zedland. On which day was the difference between the highest and lowest temperatures 10 °C?

Ⓐ Wednesday
● Thursday
Ⓒ Friday
Ⓓ Saturday

Country	Percent Correct
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.10: *Mathematics Intermediate International Benchmark*

Figure 7.11 presents an example of a Science intermediate international benchmark structured item from Biology content domain at application level of the cognitive domain. England scored the highest with 82%, with Lebanon scoring the least with 8%. Botswana scored 12% far much below the International average of 51%. Thus only 12% of Botswana students got the item correct compared to 82% of England and 51% internationally. The item was extremely difficult for Botswana students.

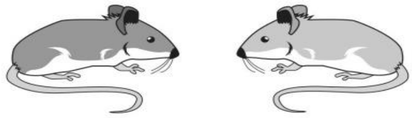
TIMSS 2015 Science 8th Grade

Exhibit 2.12.1: Intermediate International Benchmark – Example Item 1

Country	Percent Full Credit	
England	82 (1.7)	▲
† United States	82 (1.0)	▲
Norway (9)	80 (2.0)	▲
Japan	80 (1.6)	▲
Russian Federation	79 (2.0)	▲
Hungary	77 (2.2)	▲
Ireland	77 (2.0)	▲
1 † Canada	76 (1.6)	▲
Sweden	76 (2.0)	▲
Turkey	73 (1.9)	▲
Chinese Taipei	73 (1.8)	▲
† New Zealand	73 (1.6)	▲
2 Lithuania	72 (2.0)	▲
Australia	71 (1.5)	▲
Slovenia	69 (2.0)	▲
Chile	67 (2.0)	▲
2 Singapore	63 (1.8)	▲
2 Italy	60 (2.6)	▲
Korea, Rep. of	56 (2.1)	▲
Malta	56 (2.1)	▲
Hong Kong SAR	55 (2.4)	
Kazakhstan	53 (2.8)	
International Avg.	51 (0.3)	
3 Israel	51 (2.0)	
Bahrain	43 (2.2)	▼
Oman	43 (1.5)	▼
United Arab Emirates	40 (1.6)	▼
1 2 Georgia	38 (2.4)	▼
Thailand	36 (2.3)	▼
Qatar	31 (1.5)	▼
Iran, Islamic Rep. of	30 (2.0)	▼
Kuwait	27 (2.3)	▼
Malaysia	17 (1.3)	▼
Saudi Arabia	16 (1.8)	▼
Morocco	15 (1.4)	▼
Jordan	14 (1.2)	▼
Egypt	13 (1.4)	▼
South Africa (9)	13 (1.7)	▼
Botswana (9)	12 (1.1)	▼
Lebanon	8 (1.3)	▼

Content Domain: Biology
Cognitive Domain: Applying
Description: Explains the advantage for a species of mice to have coloring matching its environment

Deer mice live across much of the world. Those living in woodlands have dark brown fur. Those living on sandy beaches have light brown fur.



woodland deer mouse — beach deer mouse

Why is it an advantage for mice living on the beach to have light brown fur?

It helps the mice blend in with the sand.

The answer shown illustrates the type of response that would receive full credit (1 point).

Country	Percent Full Credit
Benchmarking Participants	

Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.11: *Science Intermediate International Benchmark*

Figure 7.12 shows an example of a Science intermediate international benchmark multiple choice item from Chemistry content domain at application level of the cognitive domain. Russian Federation scored the highest with 90%, with Saudi Arabia scoring the least with 44%. Botswana scored 71% above the International average of 68%, suggesting that item was relatively easy for Botswana students. Thus 71% of Botswana students got the item correct compared to 90% of Russian Federation and 68% internationally.

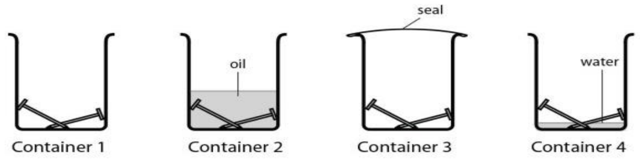
TIMSS 2015 Science 8th Grade

Exhibit 2.12.2: Intermediate International Benchmark – Example Item 2

Country	Percent Correct	
Russian Federation	90 (1.2)	▲
Chinese Taipei	88 (1.1)	▲
2 Lithuania	87 (1.5)	▲
Sweden	82 (1.9)	▲
Norway (9)	80 (1.4)	▲
Ireland	79 (1.7)	▲
Hungary	77 (1.9)	▲
Malaysia	77 (1.5)	▲
1 † Canada	77 (1.4)	▲
2 Singapore	77 (1.3)	▲
Hong Kong SAR	76 (2.1)	▲
† New Zealand	76 (1.6)	▲
Kazakhstan	76 (2.1)	▲
Japan	76 (1.7)	▲
Slovenia	75 (2.7)	▲
Korea, Rep. of	74 (1.9)	▲
2 Italy	73 (2.5)	
Australia	73 (1.7)	▲
Chile	72 (1.7)	▲
Botswana (9)	71 (1.6)	
† United States	70 (1.5)	
Iran, Islamic Rep. of	70 (1.8)	
England	70 (2.0)	
International Avg.	68 (0.3)	
Thailand	68 (2.3)	
3 Israel	66 (1.8)	
Jordan	64 (2.0)	▼
1 2 Georgia	63 (2.3)	▼
Malta	63 (2.1)	▼
Morocco	62 (1.4)	▼
Egypt	61 (1.7)	▼
Qatar	56 (2.8)	▼
South Africa (9)	55 (1.9)	▼
Bahrain	54 (2.0)	▼
United Arab Emirates	53 (1.1)	▼
Lebanon	52 (2.5)	▼
Turkey	47 (1.7)	▼
Kuwait	46 (2.3)	▼
Oman	45 (1.9)	▼
Saudi Arabia	44 (2.1)	▼

Content Domain: Chemistry
Cognitive Domain: Applying
Description: Uses information from an investigation to recognize the condition under which nails would rust most

Four students investigated the rusting of nails.
Khaled put 2 nails in Container 1.
Gabriela put 2 nails in Container 2 and covered them with oil.
Harold put 2 nails in Container 3 and sealed it.
Esmeralda put 2 nails in Container 4 and poured a little water in it.



After one week, in which container will the nails have rusted the most?

Ⓐ Container 1
Ⓑ Container 2
Ⓒ Container 3
● Container 4

Country	Percent Correct
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.
Figure 7.12: *Science Intermediate International Benchmark*

Figure 7.13 shows an example of a Mathematics intermediate international benchmark structured item from Number content domain at knowledge level of the cognitive domain. Chinese Taipei scored the highest with 85%, with South Africa scoring the least with 23%. Botswana scored 29% far much lower than the International average of 55%. Thus only 29% of Botswana students got the item correct compared to 85% of Chinese Taipei and 55% internationally suggesting that the item was extremely difficult for Botswana students.

TIMSS 2015 Mathematics 8th Grade

xhibit 2.12.1: Intermediate International Benchmark – Example Item 1

Country	Percent Full Credit	
Chinese Taipei	85 (1.4)	↑
Hong Kong SAR	85 (1.7)	↑
2 Singapore	82 (1.5)	↑
Russian Federation	77 (2.2)	↑
Slovenia	76 (1.9)	↑
Korea, Rep. of	75 (2.0)	↑
Japan	73 (1.7)	↑
Hungary	72 (2.2)	↑
Kazakhstan	70 (2.3)	↑
1 † Canada	68 (1.7)	↑
2 Italy	65 (2.2)	↑
† United States	64 (1.7)	↑
3 Israel	63 (1.8)	↑
Ireland	63 (1.9)	↑
2 Lithuania	62 (2.3)	↑
Sweden	59 (2.9)	
Lebanon	56 (2.2)	
1 2 Georgia	56 (2.7)	
International Avg.	55 (0.3)	
Australia	55 (2.0)	
United Arab Emirates	54 (1.1)	
Norway (9)	54 (2.4)	
Malta	53 (2.0)	
England	50 (2.7)	
Qatar	49 (2.0)	↓
† New Zealand	48 (2.0)	↓
Malaysia	44 (1.9)	↓
Iran, Islamic Rep. of	42 (2.2)	↓
Morocco	42 (1.5)	↓
Turkey	41 (2.4)	↓
Bahrain	41 (1.8)	↓
Oman	40 (1.6)	↓
Egypt	40 (2.0)	↓
Thailand	39 (2.6)	↓
Kuwait	39 (2.1)	↓
Chile	38 (2.4)	↓
Jordan	34 (1.9)	↓
Saudi Arabia	30 (2.6)	↓
Botswana (9)	29 (1.7)	↓
South Africa (9)	23 (1.9)	↓

Content Domain: Number
Cognitive Domain: Knowing
Description: Recognizes the commutative property

For every whole number n, are these statements **true** or **false**?
Fill in one circle for each statement.

	True	False
$n + 4 = 4 + n$	●	Ⓑ
$n - 5 = 5 - n$	Ⓐ	●
$n \times 6 = 6 \times n$	●	Ⓑ
$n \div 7 = 7 \div n$	Ⓐ	●

The answer shown illustrates the type of response that would receive full credit (1 point).

Country	Percent Full Credit
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.13: *Mathematics Intermediate International Benchmark*

Exemplar items at the High international Benchmarks (550)

Figure 7.14 below is an example of a Mathematics intermediate international benchmark structured item from Number content domain at application level of the cognitive domain. Singapore scored the highest with 70%, with Saudi Arabia scoring the least with 2%. Botswana scored 5% far much below the International average of 31%. Thus only 5% of Botswana students got the item correct compared to 70% of Singapore and 31% internationally. This was a typical difficult High benchmark item at application level. The item proved to be extremely difficult comparatively for Botswana students.

TIMSS 2015 Mathematics 8th Grade

Exhibit 2.13.1: High International Benchmark – Example Item 1

Country	Percent Full Credit	
[2] Singapore	70 (1.6)	▲
Chinese Taipei	66 (1.8)	▲
Korea, Rep. of	63 (2.2)	▲
Hong Kong SAR	63 (2.6)	▲
Japan	62 (1.8)	▲
Ireland	55 (2.2)	▲
[1] † Canada	55 (2.1)	▲
[2] Lithuania	52 (2.3)	▲
[3] Israel	51 (2.3)	▲
Norway (9)	50 (2.4)	▲
Sweden	48 (2.3)	▲
England	48 (2.5)	▲
Hungary	48 (2.7)	▲
Russian Federation	48 (2.2)	▲
† United States	47 (1.8)	▲
† New Zealand	40 (2.0)	▲
[2] Italy	40 (2.7)	▲
Slovenia	39 (1.9)	▲
Australia	38 (1.7)	▲
Malta	37 (1.9)	▲
International Avg.	31 (0.3)	
Malaysia	21 (1.4)	▼
Turkey	21 (1.8)	▼
Kazakhstan	20 (2.2)	▼
United Arab Emirates	20 (1.0)	▼
[1 2] Georgia	18 (2.0)	▼
Qatar	17 (1.7)	▼
Thailand	14 (1.6)	▼
Chile	14 (1.5)	▼
Bahrain	11 (1.5)	▼
Oman	8 (0.9)	▼
Kuwait	8 (1.9)	▼
Iran, Islamic Rep. of	6 (1.1)	▼
Botswana (9)	5 (0.8)	▼
Lebanon	4 (1.1)	▼
South Africa (9)	4 (0.9)	▼
Egypt	4 (0.6)	▼
Morocco	4 (0.6)	▼
Jordan	3 (0.6)	▼
Saudi Arabia	2 (0.5)	▼

Content Domain: Number
Cognitive Domain: Applying
Description: Part B - Selects and combines information from two sources to solve a multi-step word problem

Mobile Telephone

Kate was going to buy a new Supertext mobile phone.

She looked at these two advertisements.

Company X	Company Y
The New Supertext Mobile Phone Get this great phone free! 250 zeds monthly charge Calls 3 zeds per minute Text messages 2 zeds each	The New Supertext Mobile Phone Cheap rates for calls and texts! Buy the phone for 2500 zeds Only 50 zeds monthly charge Calls only 2 zeds per minute Text messages only 1 zed each

Kate decided to compare how much it would cost to have the phone for a year without making any calls or sending any text messages.

A. Work out the cost of having the Supertext phone for a year from Company X and from Company Y.

Costs: Company X 3000 Company Y 3100

B. Kate then estimated how much she was likely to use the phone. She thought she would talk on the phone for 500 minutes in the first year and send 200 text messages. Find out how much she would pay for the phone in the first year from each company. Do not forget the monthly charge and other costs.

Costs: Company X 4900 Company Y 4300

The answer shown for part B illustrates the type of response that would receive full credit (2 points).

Country	Percent Full Credit

Benchmarking Participants

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.14: *Mathematics High International Benchmark*

Figure 7.15 presents an example of a Mathematics High international benchmark structured item from Algebra content domain at knowledge level of the cognitive domain. Singapore scored the highest with 77%, with Botswana scoring the least with 6%, far much below the International average of 32%. Thus only 6% of Botswana students got the item correct compared to 77% of Singapore and 32% internationally. This was a typical difficult High benchmark item at knowledge level judging by both highest and international average percent correct. The item proved to be extremely difficult for Botswana students as only 6% got the item correct

TIMSS 2015 Mathematics 8th Grade

Exhibit 2.13.3: High International Benchmark – Example Item 3

Country	Percent Full Credit	
² Singapore	77 (1.9)	▲
Hong Kong SAR	75 (2.2)	▲
Chinese Taipei	73 (1.9)	▲
Korea, Rep. of	69 (2.0)	▲
Kazakhstan	57 (2.7)	▲
Russian Federation	57 (2.3)	▲
Japan	55 (1.8)	▲
† United States	51 (1.5)	▲
Slovenia	48 (2.2)	▲
Lebanon	43 (2.6)	▲
¹ † Canada	38 (1.7)	▲
United Arab Emirates	37 (1.2)	▲
³ Israel	37 (2.1)	▲
Hungary	36 (2.3)	
Malta	36 (1.9)	
Ireland	35 (2.2)	
¹ ² Georgia	35 (2.7)	
² Italy	33 (2.3)	
² Lithuania	32 (2.1)	
International Avg.	32 (0.3)	
Australia	28 (2.0)	▼
Malaysia	28 (1.6)	▼
England	26 (2.0)	▼
Egypt	23 (1.9)	▼
Bahrain	22 (2.2)	▼
Qatar	21 (1.8)	▼
† New Zealand	20 (1.8)	▼
Turkey	20 (1.8)	▼
Oman	19 (1.4)	▼
Iran, Islamic Rep. of	17 (1.4)	▼
Jordan	16 (1.4)	▼
Chile	13 (1.7)	▼
Saudi Arabia	13 (1.7)	▼
Thailand	12 (1.7)	▼
South Africa (9)	10 (1.4)	▼
Norway (9)	10 (1.4)	▼
Kuwait	10 (1.5)	▼
Sweden	8 (1.2)	▼
Morocco	8 (0.8)	▼
Botswana (9)	6 (0.9)	▼

Content Domain: Algebra
Cognitive Domain: Knowing
Description: Finds the value of an algebraic expression involving parentheses and negative terms

$a = 5$ and $b = 2$.
What is the value of $a^2b - 3(a - b)$?

Answer: 41

The answer shown illustrates the type of response that would receive full credit (1 point).

Country	Percent Full Credit
Benchmarking Participants	

Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.15: *Mathematics High International Benchmark*

Figure 7.16 presents an example of a Science High international benchmark multiple choice item from Earth Science content domain at knowledge level of the cognitive domain. Russian Federation scored the highest with 70%, with Botswana scoring the least with 7%, far much below the International average of 44%. Thus only 7% of Botswana students got the item correct compared to 70% of the Russian Federation and 44% internationally. The item was extremely difficult for Botswana students.

TIMSS 2015 Science 8th Grade

Exhibit 2.13.5: High International Benchmark – Example Item 5

Country	Percent Correct
Russian Federation	70 (2.3)
† United States	69 (1.5)
† New Zealand	68 (2.2)
Australia	63 (2.0)
2 Lithuania	59 (2.3)
Slovenia	58 (2.4)
Sweden	55 (2.7)
Hong Kong SAR	54 (2.4)
2 Italy	54 (2.2)
Qatar	52 (2.0)
Bahrain	52 (2.2)
2 Singapore	51 (1.7)
Norway (9)	51 (2.2)
Chinese Taipei	51 (1.7)
Oman	50 (2.0)
England	50 (2.3)
Kazakhstan	49 (2.4)
Ireland	48 (2.3)
Thailand	48 (2.4)
Chile	46 (2.2)
1 † Canada	46 (1.8)
Korea, Rep. of	45 (2.2)
Kuwait	45 (2.1)
International Avg.	44 (0.3)
United Arab Emirates	44 (1.6)
Saudi Arabia	44 (2.4)
3 Israel	42 (1.8)
Turkey	38 (2.2)
Iran, Islamic Rep. of	37 (2.0)
Hungary	36 (2.1)
Japan	35 (1.9)
Jordan	34 (2.0)
Malaysia	33 (1.7)
Morocco	33 (1.6)
1 2 Georgia	31 (2.4)
Egypt	30 (2.0)
Malta	29 (1.7)
South Africa (9)	16 (1.7)
Lebanon	13 (1.7)
Botswana (9)	7 (1.0)

Content Domain: Earth Science

Cognitive Domain: Knowing

Description: Recognizes a consequence of the gravitational pull of the Moon on Earth

Which of the following results from the gravitational pull of the moon on Earth?

Ⓐ earthquakes

● high and low tides

Ⓒ full eclipse of the sun

Ⓓ rotation of Earth on its axis

Country	Percent Correct

Benchmarking Participants

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.16: Science *High International Benchmark*

Figure 7.17 presents an example of a Science High international benchmark structured item from Physics content domain at reasoning level of the cognitive domain. Singapore scored the highest with 85%, with Egypt scoring the least with 12%. Botswana scored 26% far much below the International average of 47%. Thus only 12% of Botswana students got the item correct compared to 85% of Singapore and 47% internationally. This item was difficult for Botswana students.

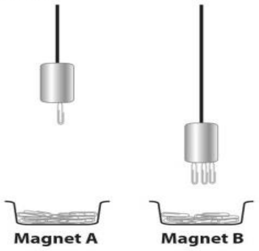
TIMSS 2015 Science 8th Grade

Exhibit 2.13.4: High International Benchmark – Example Item 4

Country	Percent Full Credit	
² Singapore	85 (1.2)	▲
Chinese Taipei	75 (1.6)	▲
Slovenia	74 (2.0)	▲
Hong Kong SAR	71 (2.4)	▲
Australia	66 (1.8)	▲
Norway (9)	65 (2.2)	▲
† New Zealand	65 (1.6)	▲
England	65 (2.4)	▲
Ireland	62 (2.2)	▲
1 † Canada	60 (1.9)	▲
† United States	58 (1.7)	▲
2 Lithuania	58 (2.0)	▲
2 Italy	57 (1.8)	▲
Korea, Rep. of	56 (1.9)	▲
Malta	55 (1.9)	▲
Sweden	53 (2.8)	▲
Japan	50 (1.9)	
Hungary	50 (2.5)	
Russian Federation	49 (2.8)	
3 Israel	49 (1.8)	
Iran, Islamic Rep. of	48 (1.8)	
International Avg.	47 (0.3)	
Kazakhstan	46 (2.9)	
United Arab Emirates	46 (1.2)	
Turkey	44 (2.3)	
Bahrain	43 (1.7)	▼
Oman	42 (1.5)	▼
Thailand	40 (2.1)	▼
Malaysia	39 (1.8)	▼
Qatar	36 (1.8)	▼
Chile	35 (2.1)	▼
Botswana (9)	26 (1.6)	▼
Lebanon	26 (2.4)	▼
South Africa (9)	26 (1.5)	▼
Jordan	25 (1.6)	▼
Kuwait	25 (2.5)	▼
Saudi Arabia	22 (1.8)	▼
1 2 Georgia	19 (2.0)	▼
Morocco	14 (1.2)	▼
Egypt	12 (1.1)	▼

Content Domain: Physics
Cognitive Domain: Reasoning
Description: Explains whether a conclusion can be made about the relative strength of two magnets in a given context

Two magnets, A and B, are each brought near a tray of metal paper clips and held at a fixed distance.



Tina considers the setup and concludes that Magnet B is stronger than Magnet A.

Do you agree with Tina's conclusion?

(Check one box.)

☐ Yes

☑ No

Explain your answer.

The magnets are not the same distance away from the paperclips.

The answer shown illustrates the type of response that would receive full credit (1 point).

Country	Percent Full Credit
Benchmarking Participants	

Source: IEA's trends in international mathematics and science study – TIMSS 2015.

Figure 7.17: Science *High International Benchmark*

Exemplar items at the Advanced International Benchmarks (625)

Figure 7.18 shows an example of a Mathematics Advanced international benchmark structured item from Number content domain at reasoning level of the cognitive domain. Japan scored the highest with 58%, and Morocco scored the least with 2%. Botswana scored 3% far much below the International average of 20%. Thus only 3% of Botswana students got the item correct compared to 58% of Japan and 20% internationally. This item was extremely difficult item for Botswana students.

TIMSS 2015 Mathematics 8th Grade

Exhibit 2.14.1: Advanced International Benchmark – Example Item 1

Country	Percent Full Credit	
Japan	58 (1.9)	▲
[2] Singapore	54 (2.0)	▲
Chinese Taipei	50 (2.1)	▲
Korea, Rep. of	48 (2.1)	▲
Norway (9)	40 (2.0)	▲
Hong Kong SAR	39 (2.5)	▲
England	33 (1.8)	▲
[1] † Canada	32 (1.7)	▲
Ireland	32 (2.1)	▲
Slovenia	30 (2.0)	▲
Hungary	27 (1.9)	▲
[3] Israel	27 (1.8)	▲
Kazakhstan	26 (1.8)	▲
† New Zealand	24 (1.4)	▲
Australia	24 (1.5)	▲
Sweden	23 (2.2)	
Malta	23 (1.7)	
† United States	22 (1.3)	
Russian Federation	21 (1.6)	
International Avg.	20 (0.2)	
Turkey	20 (1.8)	
[2] Italy	16 (1.3)	▼
[2] Lithuania	15 (1.7)	▼
[1] [2] Georgia	14 (1.9)	▼
Lebanon	10 (1.3)	▼
United Arab Emirates	10 (0.8)	▼
Chile	9 (1.1)	▼
Qatar	8 (1.0)	▼
Malaysia	7 (0.9)	▼
Bahrain	7 (0.9)	▼
Iran, Islamic Rep. of	5 (1.2)	▼
Kuwait	5 (0.9)	▼
Egypt	4 (0.8)	▼
Thailand	4 (0.9)	▼
South Africa (9)	4 (0.8)	▼
Oman	4 (0.5)	▼
Saudi Arabia	4 (1.0)	▼
Jordan	3 (0.7)	▼
Botswana (9)	3 (0.5)	▼
Morocco	2 (0.3)	▼

Content Domain: Number
Cognitive Domain: Reasoning
Description: Reasons about fractional parts of a whole in a word problem and explains answer

Tom and his brother Peter received the same amount of money.

Tom spent $\frac{1}{3}$ of his money on books. He spent $\frac{3}{5}$ of the remaining money to buy a new pair of shoes.

Peter spent $\frac{3}{5}$ of his money to buy a new pair of shoes.

Who spent more for shoes?

(Check one box.)

- ☐ Tom spent more money for shoes.
- ☒ Peter spent more money for shoes.
- ☐ They both spent the same amount for shoes.

Explain your answer.

$\frac{2}{3} \times \frac{3}{5} = \frac{2}{5}$

The answer shown illustrates the type of response that would receive full credit (1 point).

Country	Percent Full Credit
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.18: *Mathematics Advanced International Benchmark*

Figure 7.19 shows an example of a Mathematics Advanced international benchmark multiple choice item from Geometry content domain at reasoning level of the cognitive domain. Chinese Taipei scored the highest with 72%, and Sweden scored the least with 18%. Botswana scored 22%, below the International average of 32%. Thus 22% of Botswana students got the item correct compared to 72% of Taipei and 32% internationally. This item was difficult for Botswana students.

TIMSS 2015 Mathematics 8th Grade

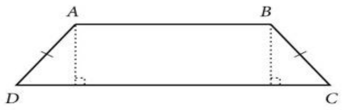
Exhibit 2.14.4: Advanced International Benchmark – Example Item 4

Country	Percent Correct	
Chinese Taipei	72 (1.6)	▲
2 Singapore	68 (1.8)	▲
Hong Kong SAR	55 (2.5)	▲
Korea, Rep. of	48 (2.3)	▲
Kazakhstan	47 (2.9)	▲
2 Italy	46 (2.4)	▲
Japan	45 (2.3)	▲
Russian Federation	43 (2.5)	▲
3 Israel	40 (2.1)	▲
Hungary	38 (2.4)	▲
Turkey	38 (1.8)	▲
2 Lithuania	34 (2.3)	
† United States	33 (1.6)	
International Avg.	32 (0.3)	
1 † Canada	31 (1.6)	
England	31 (2.0)	
Malaysia	31 (1.8)	
1 2 Georgia	29 (2.7)	
Oman	28 (1.5)	▼
Iran, Islamic Rep. of	28 (2.1)	▼
Egypt	28 (1.7)	▼
Australia	27 (1.6)	▼
United Arab Emirates	26 (1.3)	▼
Slovenia	26 (1.8)	▼
† New Zealand	26 (1.7)	▼
Morocco	25 (1.4)	▼
Jordan	25 (1.8)	▼
Norway (9)	25 (2.0)	▼
Malta	25 (1.8)	▼
Ireland	25 (2.0)	▼
Thailand	24 (1.7)	▼
Chile	24 (1.9)	▼
Qatar	23 (1.6)	▼
Bahrain	23 (1.5)	▼
Botswana (9)	22 (1.6)	▼
Kuwait	21 (2.3)	▼
Saudi Arabia	20 (2.0)	▼
South Africa (9)	20 (1.3)	▼
Lebanon	18 (1.9)	▼
Sweden	18 (1.9)	▼

Content Domain: Geometry

Cognitive Domain: Reasoning

Description: Uses the Pythagorean theorem in finding the perimeter of a trapezoid



$ABCD$ is a trapezoid with $AB = 10$ cm and $CD = 16$ cm. $AD = BC$.
The distance between the parallel lines, AB and CD, is 4 cm. What is its perimeter?

- ● 36 cm
- Ⓑ 34 cm
- Ⓒ 32 cm
- Ⓓ 30 cm

Country	Percent Correct
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.19: *Mathematics Advanced International Benchmark*

Figure 7.20 shows an example of a Science Advanced international benchmark structured item from Chemistry content domain at application level of the cognitive domain. Chinese Taipei scored the highest with 71%, while Saudi Arabia scored the least with 5%. Botswana scored 15%, below the International average of 30%. Thus only 15% of Botswana students got the item correct compared to 71% of Chinese Taipei and 30% internationally. This item was difficult for Botswana students.

TIMSS 2015 Science 8th Grade

Exhibit 2.14.2: Advanced International Benchmark – Example Item 2

Country	Percent Full Credit	
Chinese Taipei	71 (1.6)	▲
Hong Kong SAR	70 (2.4)	▲
Ireland	48 (2.2)	▲
Korea, Rep. of	44 (2.2)	▲
[2] Singapore	42 (1.6)	▲
Russian Federation	41 (2.5)	▲
Turkey	38 (2.1)	▲
England	38 (2.1)	▲
[1] † Canada	37 (1.6)	▲
[2] Lithuania	37 (2.3)	▲
United Arab Emirates	35 (1.4)	▲
[2] Italy	34 (2.2)	▲
Kazakhstan	34 (2.6)	
Malaysia	33 (1.9)	▲
[3] Israel	33 (1.8)	
Oman	33 (1.6)	
Bahrain	32 (2.8)	
Japan	32 (1.9)	
Slovenia	31 (2.1)	
Hungary	30 (1.9)	
International Avg.	30 (0.3)	
Sweden	29 (2.9)	
Qatar	29 (1.9)	
† United States	28 (1.4)	
Lebanon	27 (2.5)	
Australia	26 (1.3)	▼
Norway (9)	26 (2.1)	
Malta	26 (1.9)	▼
Iran, Islamic Rep. of	25 (2.3)	
† New Zealand	24 (1.6)	▼
Chile	22 (1.6)	▼
Thailand	17 (1.7)	▼
Botswana (9)	15 (1.3)	▼
Jordan	15 (1.3)	▼
Kuwait	15 (1.9)	▼
[1 2] Georgia	13 (1.9)	▼
Egypt	9 (1.3)	▼
South Africa (9)	9 (1.3)	▼
Morocco	8 (0.8)	▼
Saudi Arabia	5 (1.1)	▼

Content Domain: Chemistry
Cognitive Domain: Applying
Description: Determines the color that results after a pH indicator is added to four solutions, based on information provided about the indicator

The juice of red cabbage is a natural pH indicator. The color of the juice is purple.

- When it is added to an **acid**, its color changes to **red**.
- When it is added to a **base**, its color changes to **blue**.
- When it is added to a **neutral** solution, its color remains **purple**.

Write the color of the solution after this indicator is added to each of the following.

	Color
Distilled water	purple
Lemon juice	red
Vinegar	red
Baking soda solution	blue

The answer shown illustrates the type of response that would receive full credit (1 point).

Country	Percent Full Credit
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.20: *Science Advanced International Benchmark*

Figure 7.21 shows an example of a Science Advanced international benchmark structured item from Physics content domain at application level of the cognitive domain. Singapore scored the highest with 54%, while South Africa scored the least with 4%. Botswana scored 8%, below the International average of 22%. Thus only 8% of Botswana students got the item correct compared to 54% of Singapore and 22% internationally. This item was difficult for Botswana students.

TIMSS 2015 Science 8th Grade

Exhibit 2.14.4: Advanced International Benchmark – Example Item 4

Country	Percent Full Credit
[2] Singapore	54 (2.0) ▲
Chinese Taipei	54 (1.9) ▲
Turkey	51 (2.4) ▲
Korea, Rep. of	46 (2.4) ▲
Russian Federation	45 (2.1) ▲
Kazakhstan	43 (2.8) ▲
[3] Israel	30 (1.8) ▲
Slovenia	27 (2.2) ▲
Bahrain	26 (1.9) ▲
Oman	26 (1.3) ▲
Hungary	25 (1.8) ▲
Hong Kong SAR	25 (2.3)
England	24 (1.8)
Japan	22 (1.5)
International Avg.	22 (0.3)
† United States	22 (1.2)
Qatar	21 (1.4)
Norway (9)	19 (1.7)
[2] Lithuania	19 (1.8)
Chile	19 (1.8)
Thailand	19 (1.6)
[1 2] Georgia	18 (2.0) ▼
[2] Italy	17 (1.9) ▼
United Arab Emirates	17 (0.9) ▼
Saudi Arabia	16 (1.7) ▼
[1] † Canada	15 (1.3) ▼
Jordan	15 (1.5) ▼
Sweden	14 (1.6) ▼
† New Zealand	13 (1.3) ▼
Iran, Islamic Rep. of	13 (1.6) ▼
Australia	12 (1.1) ▼
Egypt	11 (1.2) ▼
Kuwait	11 (1.3) ▼
Lebanon	10 (1.9) ▼
Malta	9 (1.3) ▼
Morocco	8 (0.9) ▼
Ireland	8 (1.1) ▼
Malaysia	8 (0.8) ▼
Botswana (9)	8 (1.1) ▼
South Africa (9)	4 (0.6) ▼

Content Domain: Physics
Cognitive Domain: Applying
Description: Interprets a diagram to describe the direction of heat flow in metals

Two metal cubes at different temperatures were placed on top of each other, as shown below.

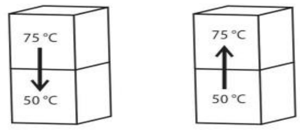


Diagram 1 Diagram 2

Which diagram shows the correct direction of heat flow?

(Check one box.)

- [x] Diagram 1
- [ ] Diagram 2

Explain your answer.

Heat moves to areas with lower temperature.

The answer shown illustrates the type of response that would receive full credit (1 point).

Country	Percent Full Credit
Benchmarking Participants	

Source: IEA's trends in International Mathematics and Science Study – TIMSS 2015.

Figure 7.21: *Science Advanced International Benchmark*

For the exemplar items presented in this chapter, Botswana generally scored below the international average indicating that the items were inaccessible to most of Botswana students including the Low benchmark items.

CHAPTER EIGHT: CURRICULUM IMPLEMENTATION

A school is an institution comprising of a teacher and school leadership such as a school head. A teacher is a resource instrument that its role cannot be ignored. A teacher is a resource provider, instructional specialist, curriculum specialist, classroom supporter, classroom facilitator, mentor, a coach, a catalyst for change to list the few.

Curriculum has varied definitions depending on the author's or practitioner's view point. For example, Wiles & Bondi (2007) defines curriculum simply as all planned occurrences in the classroom. Others narrowly define it as the content taught every day. Still others view curriculum in a manner that is more refined than all classroom occurrences and broader than content. Regardless of how it is defined, curriculum has three important components: (1) the intended outcomes, (2) what is taught, and (3) the manner of implementation. Thus curriculum spells out how it intends to produce quality graduates. Then it goes further and says what it is that needs to be taught to the students to end up with them being of desired quality. Lastly, it has to spell out how it would achieve that. That is, what resources; human resources, physical resources or time resources will be integrated to produce that desired quality product?

Thus:

- Factor 1: Curriculum implementation must be done the way it was designed to be done (i.e., with fidelity); in a consistent manner; and with challenges to students to facilitate the development and use of higher level thinking abilities.

- Factor 2: Opportunities to learn must include curricular differentiations designed to achieve desired needs or outcomes; relevant to the learner; and implemented during classroom instruction.

- Factor 3: Effectiveness of the curriculum and its implementation requires assessment that is based on the curriculum taught in the classroom; is linked directly to what has been taught; and is conducted on a regular basis to closely monitor students' progress toward curricular benchmarks.

Given the foregoing, three main components have been identified under this theme, namely:

(i) Teaching staff background which deals with the School Head and teacher background variables. It is widely documented that the quality of teaching staff is fundamental to effective curriculum implementation. Seven (7) items have been found to load onto the Teacher Background sub-component as shown in Figure 8.1

and were all from the Teacher Questionnaire, while five (5) loaded onto the School Head sub-component and were all from the School Questionnaire Figure 8.2)

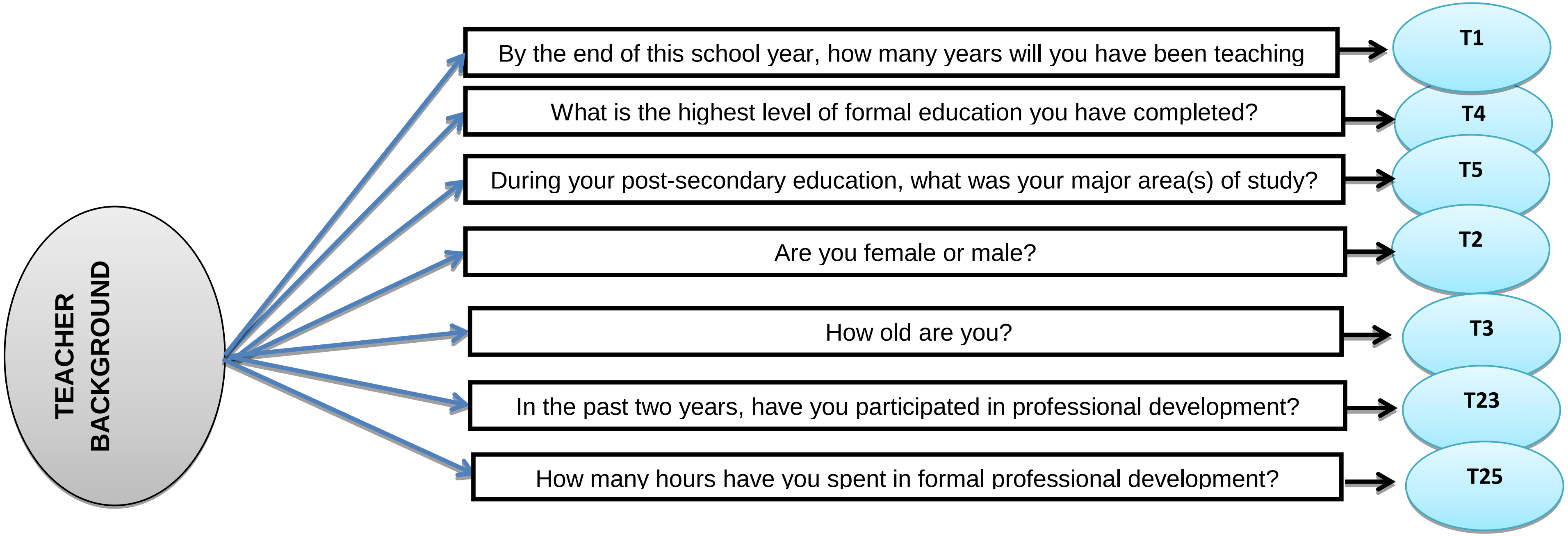


Figure 8.1: Items Loading onto the Teacher Background

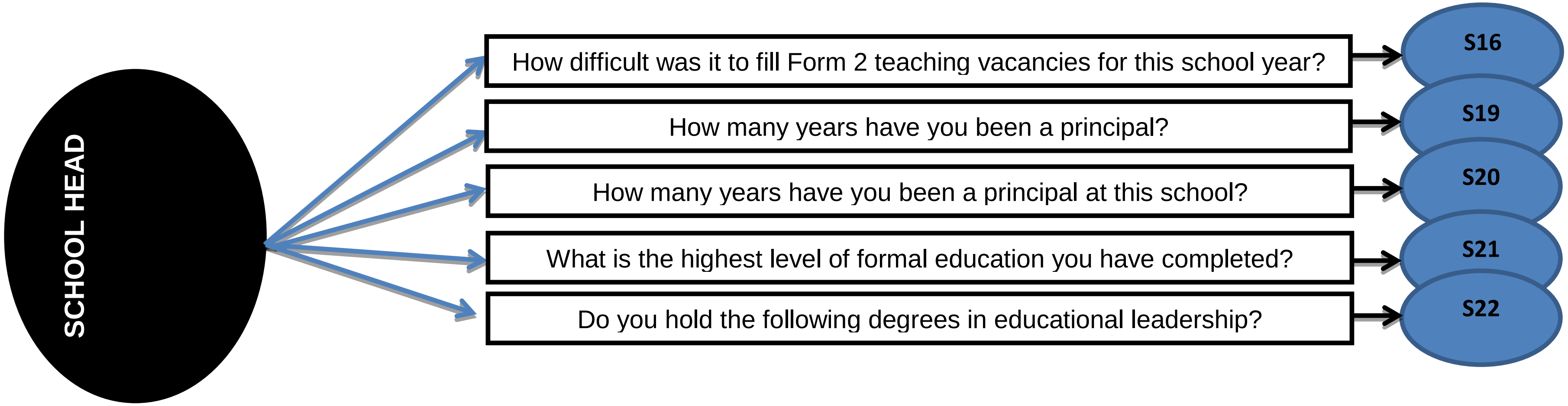


Figure 8.2: *Items Loading onto the School Head Background*

(ii) Resources: for any school to effectively implement the curriculum it needs to have adequate resources such as laboratory, classrooms, equipment, library, computers, reading materials, and others. Nine (9) items have been found to load onto this component as shown in Figure 8.3. Six (6) of the items were from the School Questionnaire and three (3) from the Teacher Questionnaire.

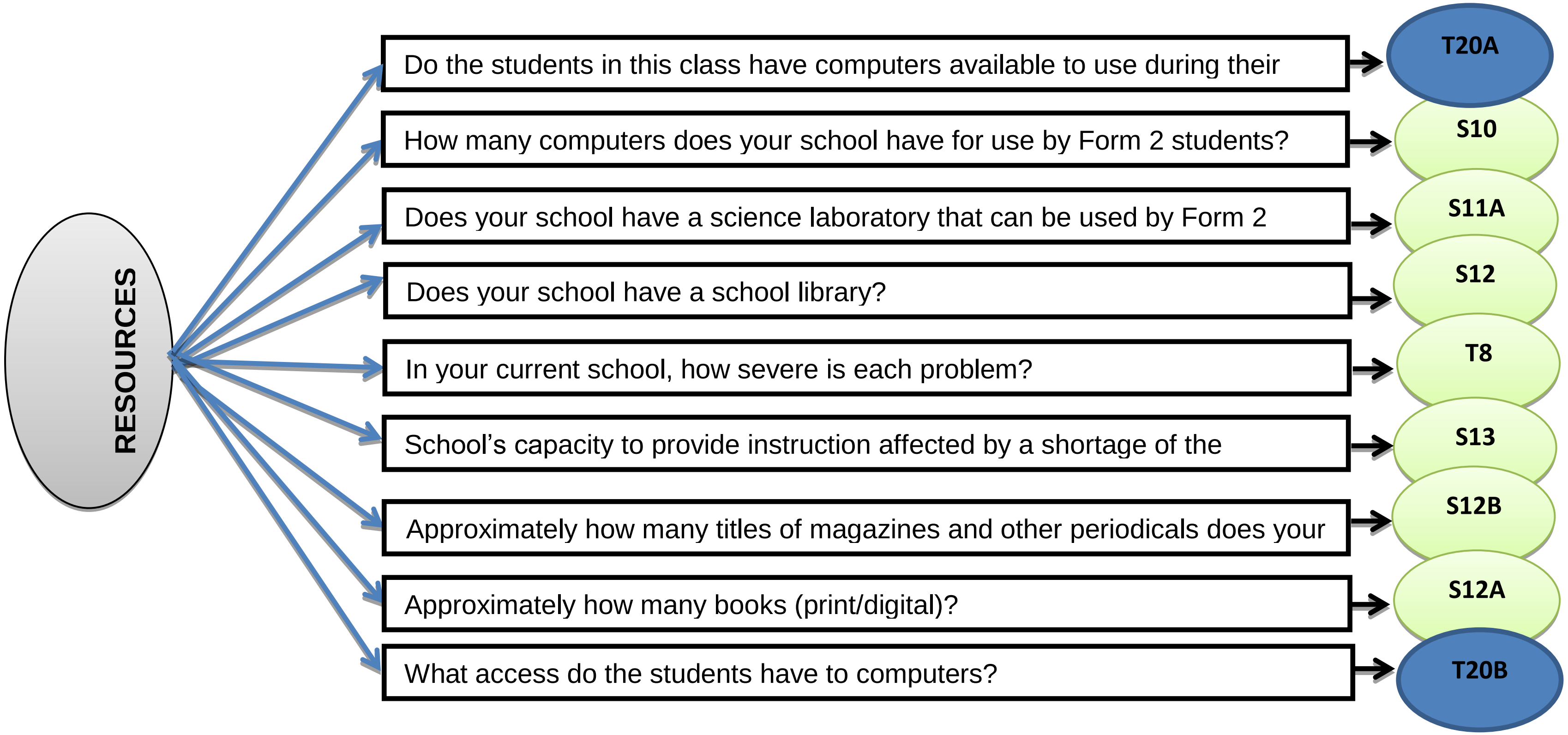


Figure 8.3: *Items Loading onto the Resources Component*

(iii) Engagement/Classroom interaction: qualified and experienced teaching staff with adequate resources plans engaging learning experiences for students. Learner centred approaches to learning require students' active participation to create their own knowledge for better understanding. Fourteen (14) items have been found to load onto this component as shown in Figure 8.4. Fourteen (14) items of which nine (9) were from Teacher Questionnaire, three (3) from Student Questionnaire and two (2) from School Questionnaire loaded onto this component. It must be noted that in some cases, the same item was included in two different questionnaires, as is the case with one item which was administered to both the Teachers and the Students.

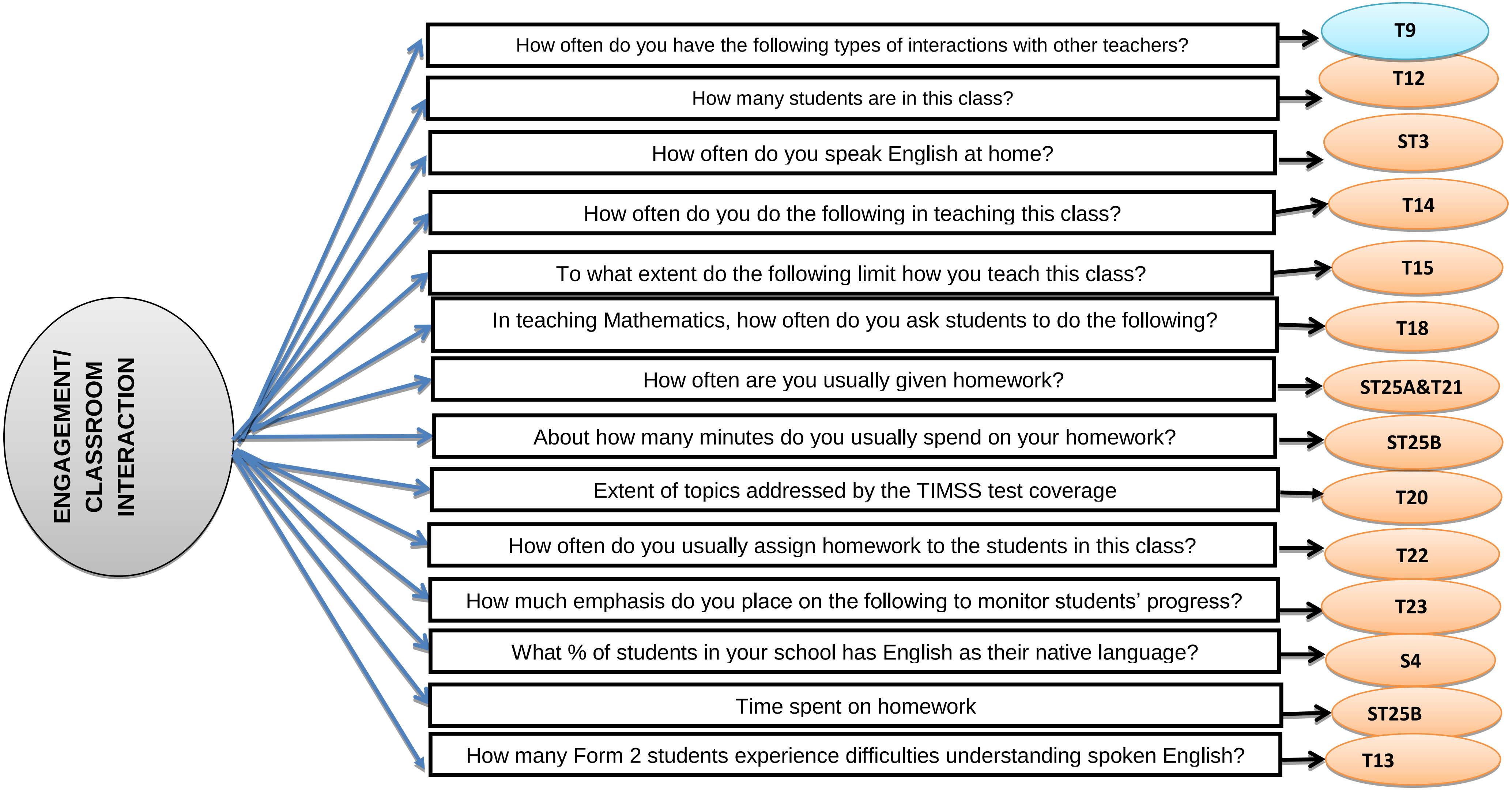


Figure 8.4: Items Loading onto Engagement/Classroom Interaction Component

In this chapter, the character or role of a teacher and that of the School Head is evaluated with the student performance.

Teaching Staff Background

Performance in Science and Mathematics by teacher experience

In this study, Mathematics and Science teachers were asked how many years they had been teaching. The teachers' responses based on this question were grouped in an interval of 5 years i.e. below 4 (0-4), 5 – 9 years, 10 – 14 years, 15 – 19 years and 20 and above. This grouping is different from that which was done in the previous study, TIMSS 2011, in which the teaching experience was grouped into an interval of ten years (1-10, 11-20 etc.). The former grouping has been informed by the teaching service criteria, in which 0-4 years teaching experience falls under the Assistant Teacher and Teacher position, while 5 years and above falls under Senior Teacher category (Senior Teacher II and I), which are positions of responsibility. Table 8.1 shows the teaching experience evaluated against the students' performance.

Table 8.1: *Performance in Science and Mathematics by Teacher Experience*

Subject	Years of teaching	n	%	Mean	SE	SD	diff
Science	≥ 4 yrs	1,750	33.29	380.55	5.40	109.71	1,2 34.39*, 1,3 9.08
	5-9 yrs	1,157	19.94	414.93	7.83	102.95	1,4 16.97, 1,5 19.45
	10-14 yrs	1,136	21.62	389.63	7.23	107.65	2,3 -25.31*, 2,4 -17.41
	15-19 yrs	1,117	18.23	397.52	7.42	103.44	2,5 -14.94, 3,4 7.89
	20 and above	551	6.91	399.99	14.00	117.90	3,5 10.37, 4,5 2.47
Mathematics	≥ 4 yrs	1,886	37.06	388.37	4.56	80.76	1,2 12.15, 1,3 -3.45
	5 to 9 yrs	1,128	21.19	400.52	5.08	81.63	1,4 -2.06, 1,5 9.22
	10 to 14 yrs	923	15.98	384.92	5.92	83.84	2,3 15.60*, 2,4 -13.21
	15 to 19 yrs	804	14.58	387.32	6.82	83.35	2,5 -2.93, 3,4 2.39
	20 and above	842	11.19	397.60	9.04	91.43	3,5 12.67, 4,5 10.28

As seen from the table, the majority of the students were taught by teachers with 0-4 years of teaching experience, , followed by those taught by teachers with 5-9 years in Mathematics while in Science, it's those with 10-14 years of teaching. The students who were taught by teachers with 0-4 years teaching experience in Science performed significantly lower than those taught by teachers with responsibility positions. In both Science and Mathematics, the students who were taught by teachers with 5-9 years performed significantly better than those who were taught by teachers with 10-14 years teaching experience.

Performance in Mathematics and Science by Gender

Since long time back, the mastery and the teaching of Science and Mathematics was dominated by males. But recently, the girl-child has been dominating the boy-child as previous TIMSS studies and examination results bear testimony. Table 8.2 shows the proportion of candidates taught by the male teachers and female teachers and their performance.

Table 8.2: *Performance in Mathematics and Science by Sex*

Subject	Gender	N	%	Mean	SE	SD
Mathematics	Female	2,367	43.75	391.16	3.86	82.91
	Male	3,174	56.25	390.83	3.35	83.73
Science	Female	2,220	43.50	401.23	5.72	107.03
	Male	3,491	56.50	388.09	3.77	108.66

The results show that, most of the students were taught by male teachers in both Science (56.50%) and Mathematics (56.25%). However, performance in Science shows that students taught by female teachers performed higher than those taught by male teachers whereas in Mathematics, the gender of the teacher is not related to performance.

Performance in Science and Mathematics by Level of Education

The teachers were asked to indicate their highest level of formal education, which was then related to students' performance as shown in Table 8.3.

Table 8.3: *Performance of Students in Science and Mathematics by Level of Teacher Education*

			Science		Mathematics	
Level of Education	n	%	Mean	SD	Mean	SD
Upper Secondary	66	2.73	396.71	95.95	394.13	70.64
Short-cycle tertiary	1,671	59.06	404.11	106.14	399.28	81.95
Bachelor's or equivalent	1,380	37.41	391.96	109.80	390.49	82.60
Master's or equivalent	103	0.80	556.22	60.28	535.04	58.25

Most of the students (59.06%) were taught by teachers who had completed Diploma level, followed by those (about 37%) taught by teachers with a Bachelor degree or equivalent. It is gratifying to note that almost all students (97.37%) were taught by qualified teachers. However, after 50 years of independence, there shouldn't be any unqualified teachers in schools. Government should step up the effort to replace unqualified teachers with qualified ones, and upgrade all teachers' qualifications to Master's level.

Performance of Students in Science and Mathematics by Teachers' Age

The teachers who took part in the main survey of TIMSS 2015 were asked to indicate their age, in order to find whether age has an effect on the performance of the students they teach. The age of the teachers was categorised into the following: Under 25; 25 -29; 30 – 39; 40 – 49; and 50 and above. Table 8.4 indicate the age of the teachers related to students' performance.

Table 8.4: *Students' Performance in Science and Mathematics by Teachers' Age*

	Age	n	%	Mean	SE	SD
Mathematics	Under 25	331	6.65	379.28	6.45	79.43
	25–29	1,260	24.31	386.91	5.77	80.33
	30–39	2,485	46.85	393.35	4.07	83.60
	40–49	1,219	20.66	388.48	6.33	84.41
	50–59	172	1.28	439.84	73.84	100.53
	60 or more	48	0.25	508.94	13.13	49.82
Science	Under 25	189	3.50	406.78	27.64	118.81
	25–29	1,380	27.07	389.29	7.20	110.10
	30–39	2,334	41.91	393.64	4.91	105.94
	40–49	1,591	25.66	392.72	6.38	106.80
	50–59	183	1.82	452.28	31.80	106.37
	60 or more	34	0.03	544.05	18.66	71.07

In Mathematics, about 47% of the students were taught by teachers aged between 30 – 39 years, followed by those taught by teachers aged between 25 – 29 years (24%), then followed by those students taught by teachers aged 40 – 49 years. The results indicate that, the students taught by older teachers performed better than those taught by teachers who were aged below 25 years. The students taught by teachers aged 50 and above performed better than the students taught by teachers aged below 50 years. Indeed teachers grow in wisdom with their age, hence the policy should allow those teachers who are willing to stay in the profession to continue teaching even when they had reached retirement age.

In Science, just as in Mathematics about 42% of the students were taught by teachers aged between 30 and 39 , followed by those taught by teachers aged between 25 and 29 (27%), followed by those taught by teachers aged between 40 and 49 (26%). In Science, the results are mixed. Even though the results are mixed, the students taught by teachers aged above 50 years performed better than those taught by teachers aged below 50 years. As research has shown, the more one grows in teaching the more skills they develop for better content delivery.

Teacher's Main Area of Study

Mathematics and Science teachers were requested to indicate their level of speciality such as: Mathematics, Biology, Physics, Chemistry, Education-Mathematics, Education-Science, Education-General or other. Table 8.5 and Table 8.6 show the relationship between teachers' area of speciality with students' performance.

Table 8.5: *Science Teachers' Major Area of Study and Students' Performance*

Subject	Category	n	%	Mean	SE	SD
Mathematics	Yes	908	14.21	412.42	10.26	109.23
	No	4,569	85.79	392.43	3.28	107.81
Biology	Yes	2,484	44.14	392.59	4.99	110.43
	No	3,047	55.86	397.06	4.36	106.29
Physics	Yes	1,368	24.41	393.44	7.50	106.89
	No	4,109	75.59	395.87	3.58	108.66
Chemistry	Yes	1,963	33.16	394.54	6.23	109.00
	No	3,534	66.84	395.68	4.08	107.86
Education-Mathematics	Yes	538	9.75	412.71	15.12	108.47
	No	4,897	90.25	393.84	3.34	108.16
Education-Science	Yes	3,482	68.53	397.26	3.94	107.00
	No	1,995	31.47	390.96	5.62	110.76
Education-General	Yes	509	8.35	424.89	18.42	107.42
	No	4,928	91.65	391.86	3.15	107.95
Other	Yes	666	12.45	394.98	8.93	112.45
	No	4,431	87.55	395.58	3.38	107.03

In Science, most of the students (about 69%) were taught by teachers who specialised in Education-Science, followed by those students (44%) who were taught by teachers who specialised in Biology. The results shows that, the students who were taught Science by teachers who specialised in either Biology, Physics or Chemistry performed lower than those students who were taught by teachers specialised in Mathematics, Education-Science and Education-General.

Table 8.6: *Mathematics' Major Area of Study and Student Performance*

Subject	Category	n	%	Mean	SE	SD
Mathematics	Yes	3,664	68.35	392.80	3.13	84.10
	No	1,620	31.65	390.90	4.74	81.93
Biology	Yes	395	7.29	379.94	15.41	87.24
	No	4,845	92.71	393.19	2.36	83.02
Physics	Yes	588	9.67	389.49	13.06	94.04
	No	4,696	90.33	392.49	2.38	82.20
Chemistry	Yes	469	9.47	377.81	12.18	87.57
	No	4,815	90.53	393.70	2.36	82.83
Education-Mathematics	Yes	1,907	36.80	390.07	4.68	82.98
	No	3,330	63.20	393.34	3.57	83.96
Education-Science	Yes	583	11.10	389.20	5.94	82.68
	No	4,662	88.90	392.16	2.56	83.51
Education-General	Yes	523	8.88	398.38	9.16	86.81
	No	4,682	91.12	391.77	2.58	82.90
Other	Yes	1,088	22.44	402.92	5.98	80.55
	No	3,851	77.56	391.27	3.11	83.72

In Mathematics, most of the students (68%) were taught by teachers who specialised in Mathematics followed by those taught by teachers who specialised in Education-Mathematics (37%). Students who were taught Mathematics by teachers who had specialised in Science performed lower than those students who were taught Mathematics by teachers who had speciality in Mathematics.

School Head Years of Experience Altogether

The school heads were asked to indicate the years they have been in that position. The school heads' years in those particular schools were related to the students' performance in Table 8.7.

Table 8.7: *School Heads' Experience and Student Performance*

Subject	No of years	n	%	Mean	SE	SD
Mathematics	0-5 years	2,144	42.67	387.97	3.65	82.00
	6-10 years	2,101	34.93	393.85	4.97	83.45
	11-15 years	739	11.55	392.54	3.74	82.71
	16 years and above	723	10.86	395.67	8.77	86.39
Science	0-5 years	2,144	42.67	387.84	4.73	108.10
	6-10 years	2,101	34.93	397.55	6.27	107.96
	11-15 years	739	11.55	391.57	4.68	107.38
	16 years and above	723	10.86	395.11	10.46	111.23

The majority (about 43%) of the students came from schools which were supervised by School Heads who have been in that position for 0 – 5 years, followed by those supervised by School Heads with 6 – 10 years' experience (about 35%). The results indicated that School Heads' experience was positively correlated with students' performance.

School Head's Stay at School and Students' Performance

The school heads were asked to indicate the years they have been school heads in those schools by the time the study was conducted. Table 8.8 shows school head's stay in school and student performance.

Table 8.8: *School Head's stay in a School and Student Performance*

No of Years	n	%	Mathematics			Science		
			Mean	SE	SD	Mean	SE	SD
0-5 years	3,987	74.29	393.09	2.76	81.23	394.47	3.64	105.96
6-10 years	1,283	20.37	386.40	6.49	85.77	387.19	8.58	112.99
11-15 years	223	1.66	436.20	32.80	109.00	442.08	37.55	129.74
16 years and above	214	3.68	364.32	12.37	81.78	358.45	12.97	108.98

The majority (about 74%) of the students came from schools which were supervised by school heads who have been in those schools for 0 – 5 years, followed by those schools supervised by school heads with 6 – 10 years stay in those particular schools. There are school heads who have been in the same schools for more than 10 years. It can be inferred that school heads should not stay too short nor too long a time in the same school, but rather be given reasonable time to implement their strategic plans.

School Head's Highest Level of Education and Student Performance

The questionnaire requested the school heads to state their highest level of formal education they have completed. Table 8.9 related students' performance with the School Heads' highest level of formal education.

Table 8.9: *School heads' highest level of education and students' performance.*

			Mathematics			Science		
Category	n	%	Mean	SE	SD	Mean	SE	SD
Did not complete Bachelor's or equivalent	728	11.90	381.07	3.94	80.76	376.77	4.84	105.03
Bachelor's or equivalent	4,170	76.32	390.90	2.72	82.73	392.23	3.68	108.60
Master's or equivalent	765	11.78	407.67	7.82	85.86	412.56	9.52	107.54

Most students came from schools with school heads who have completed Bachelor's degree or equivalent, while almost the same percentage of students came from schools with school heads who had completed 'Masters or equivalent' or who 'did not complete bachelor's or equivalent'. The results show that the level of formal education has a serious impact on students' performance as the students found in schools with school heads with Master's degree or equivalent surpassed the students with school heads with a lower level of education completed. The Government has a challenge to revisit her policies on sponsorship towards improving the level of education of school heads and not just school heads, but also the teachers, to the highest level of education, especially up to Master's degree. Thus school heads with Master's degree or equivalent proved to have better leadership skills as compared to those with less.

School Head's Highest Level in Educational Leadership and Students' Performance

The school heads were also asked to indicate their highest level of training in educational leadership and their responses are equated with the students' performance. Table 8.10 shows a summary of the results.

Table 8.10: *School Head's Highest Level in Educational Leadership and Students' Performance*

			Mathematics			Science		
	n	%	mean	SE	SD	Mean	SE	SD
Yes	620	10.58	403.29	7.72	80.13	407.52	9.58	102.93
No	5,053	89.42	390.32	2.40	83.34	391.14	3.14	108.86

The results indicate that most school heads had no Master's degree in educational leadership as only about 11% of the students came from schools with school heads with such a qualification.
The level of education showed that it mattered a lot as students in schools led by school heads with Master's degree in educational leadership performed better.

Teachers' Attendance in Workshops in Science and Mathematics Related to Students' Performance

The Mathematics and Science teachers were asked to indicate whether they had an opportunity to participate in professional development in their respective subject content, pedagogy/instruction, curriculum, integrating information into the subject, improving students' critical thinking or problem solving skills, subject assessment and addressing individual students' needs. An index was made such that if teachers who had attended four or more professional development workshops were categorised as has 'adequately attended', while those teachers with 2-3 professional developments as 'moderately attended' and those with one to none professional development as 'never or almost attended'. The students' performance was related to how their teachers had attended the professional development, which is summarised in table 8.11.

Table 8.11: *Teacher's professional development and students' performance*

Subject	Frequency of attendance	n	%	Mean	SD
Mathematics	Adequately attended	1,037	19.14	391.29	78.22
	Moderately attended	1,579	33.84	390.32	83.06
	Never or almost never attended	2,589	47.02	388.56	84.66
Science	Adequately attended	814	13.08	414.07	103.13
	Moderately attended	1,422	23.61	395.58	107.16
	Never or almost never attended	3,401	63.31	388.76	109.08

In Mathematics, the majority of students (about 47%) were taught by teachers who indicated that they 'never or almost never' attended professional development, followed by those students whose teachers attended professional development moderately. There is not much difference in student performance between all groups of teachers.

In Science, as in Mathematics, about 63% of the students were taught by teachers who had 'never or almost never' attended professional development. The students' performance based on how teachers were professionally developed is distinctively observed, with students taught by teachers who had adequately attended being the best, while those students taught by teachers who had 'never or almost never' attended professional development being the lowest.

Teachers' professional development is an important matter, more especially where the education system is marred with declining student performance in levels of our education system. The government has to put more resources on teacher professional development as this variable showed that most of the teachers did not attend any professional development.

Preparation of Science Teachers towards Lessons and Students Performance

To enhance learning, the government emphasises that, all classroom facilitators should prepare for every lesson, and this is indicated through lesson plans which are kept as a record. A teacher is a classroom facilitator, therefore, for effective content delivery to the learners to take place one has to spend time researching for the coming lessons. Mathematics and Science teachers in this study were asked to indicate how well prepared they were to teach Biology, Chemistry, Physics and Earth Science topics. While Mathematics teachers were asked how well they were prepared to teach topics under Number, Geometry, Algebra, and Data and chance. The teachers were advised that if a topic was not in the Form 2 curriculum or the teacher was not responsible for teaching that particular topic, then they should choose 'Not applicable'. Other choices that the teachers were given were; 'very well prepared', 'somewhat prepared', and 'not well prepared'. Their responses on their preparedness to teach Science and Mathematics topics were related to students' performance as indicated in Table 8.12.

Table 8.12: *Preparation of Science Teachers towards Lessons and Students' Performance*

Content Domain	Extent of Preparedness	n	%	Mean	SE	SD
Biology	Not applicable	159	2.85	386.02	26.84	117.18
	Very well prepared	4,979	94.27	392.66	3.23	107.49
	Somewhat prepared	113	2.88	385.18	10.15	113.76
Chemistry	Not applicable	824	15.46	381.03	9.58	111.20
	Very well prepared	4,507	80.25	397.13	3.39	107.11
	Somewhat prepared	222	3.81	373.15	18.19	111.73
	Not well prepared	43	0.49	381.43	0.91	89.78
Physics	Not applicable	436	7.20	384.37	17.37	117.87
	Very well prepared	4,517	79.24	394.17	3.05	107.78
	Somewhat prepared	643	13.56	395.57	9.69	104.09
Earth Science	Not applicable	935	13.81	390.51	9.19	111.68
	Very well prepared	3,251	60.16	393.85	3.78	107.82
	Somewhat prepared	1,361	25.78	393.14	7.10	106.35
	Not well prepared	45	0.25	526.15	7.18	60.35

In Science, most of the students were taught Science by teachers who reported that, they were 'well prepared' to teach Science topics under Biology, Physics and Chemistry.

Biology

In Biology, about 94% of the students were taught Biology by teachers who said they were well prepared to teach, and those students performed better than those taught by teachers who said they were 'somewhat prepared' and 'not applicable. About 3% of the students were taught Biology topics by teachers who indicated that some topics in Biology were 'not applicable' that is, the topics were not in Form 2 curriculum or the teachers were not responsible to teach the topics.

Chemistry

In Chemistry, about 80% of the students were taught the discipline by teachers who indicated that, they were 'well prepared' to teach the topics. This Science discipline proved to have the highest students (15%) who were taught by teachers who indicated that some topics were 'not applicable'. Students taught by teachers who were 'Well prepared' performed better than those students who taught by teachers who were 'not prepared, and 'somewhat prepared'.

Physics

In Physics, just like in Chemistry, about 79% of students were taught by teachers who were 'well prepared' and the group performed at par with those students taught by the 'somewhat prepared' teachers. About 8% of the students were taught Physics topics by teachers who indicated that some topics were 'not applicable' and the group performed dismally as compared to other groups.

Earth Science

As compared to other Science branches, Earth Science has the least of students taught by teachers who were 'Very well prepared', about 60%. Just like Chemistry, most of the content materials taught to students comes after Form 2 or not in the syllabus, as about 13% of students were taught by teachers who chose 'Not applicable' option.

Preparation of Mathematics teachers towards lessons related to students performance

The teachers' preparedness to teach Mathematics topics was related to students' performance. The results are displayed in table 8.13.

Table 8.13: *Preparation of Mathematics Teachers towards Lessons Related to Students' performance*

	Extent of preparedness	n	%	Mean	SE	SD
Number	Not applicable	753	15.78	375.66	7.84	82.07
	Very well prepared	4,581	80.78	394.21	2.62	83.34
	Somewhat prepared	182	3.43	401.53	10.47	73.93
Algebra	Not applicable	411	8.44	376.98	5.99	78.79
	Very well prepared	4,759	85.03	392.97	2.56	83.58
	Somewhat prepared	346	6.52	391.63	8.67	80.92
Geometry	Not applicable	208	4.18	348.83	5.05	77.28
	Very well prepared	4,996	90.20	394.13	2.39	82.91
	Somewhat prepared	312	5.62	381.61	6.51	81.48
Data and chance	Not applicable	586	12.08	379.54	3.98	79.23
	Very well prepared	4,436	78.79	393.81	2.82	83.87
	Somewhat prepared	494	9.13	387.78	5.48	80.25

In Mathematics branches, most of the students were taught by teachers who were 'Very well prepared' to teach Geometry (90%), followed by Algebra with 85%, followed by Number with about 81% and the least being Data and Chance at 79%. In all the topics except Geometry (about 4% of students), more than 8% of the students were taught by teachers who indicated that some materials in these topics were 'not applicable'. Where teachers were very well prepared, the students performed much better.

For effective learning to take place in the teaching fraternity, the school has to provide a conducive environment for the learners, in terms of resources such as teaching facilities, computers etc. In order to assess whether schools had appropriate facilities to enhance learning, students, teachers and school heads were asked to provide information about such relevant resources.

The use of Computers

The study assessed the effect of computer usage in Mathematics and Science teaching. The teachers were asked about the availability of computers during the teaching of their respective subjects, and their responses were related to student performance. Tables 8.14 and Table 8.15 show the results.

Availability of computers during science lessons

Science teachers were asked on whether there are computers available to be used by learners during science lessons. Their responses are related to students' performance in Table 8.14.

Table 8.14: *Use of Computers during Science Lessons and Students' Performance*

	n	%	Mean	SE	SD
Yes	452	7.36	367.84	10.09	109.54
No	5,056	92.64	396.30	2.99	107.44

About 92% of the students were in schools where teachers indicated that they do not use computers during the science teaching, and the same group performed better than the students taught by teachers who use computers during teaching time.

Use of computers during science lessons

The teachers were asked to indicate whether their students share computers or not or use computers sometimes during Science lessons. Table 8.15 shows a summary of the results.

Table 8.15: *Use of Computers during Science Lessons and Students' Performance*

Availability of computers	Category	n	%	Mean	SE	SD
Each student has a computer	Yes	38	0.47	540.34	11.94	68.96
	No	414	99.53	367.02	10.11	109.04
Student sharing computers in class	Yes	108	25.31	360.82	15.56	103.22
	No	344	74.69	370.22	13.02	111.42
School has computers used sometimes	Yes	374	76.15	365.31	12.47	109.37
	No	78	23.85	375.94	17.87	109.47

Very few centres have computers for usage during their Science lessons. About 38 students out of 452 were taught by teachers who indicated that their students do not share computers during their Science lessons, while 108 students out of 452 had their students sharing computers and about 374 students out of 452 were taught by teachers who indicated that their students use computers sometimes. The results show that where students do not share computers during lessons they perform best, but where they share or use computers sometimes they perform lowest.

The study also investigated on how often students 'practice skills and procedures'; 'look up ideas and information', 'do scientific procedures or experiments', 'study natural phenomena through simulations' and 'process and analyse data' on computers during Science lessons. The results are presented in table 8.16.

Table 8.16: *Activities on Computers by Students during Science Lessons and Student Performance*

		n	%	Mean	SE	SD
Practice skills and procedures	Once or twice a week	66	1.02	544.46	8.41	64.81
	Once or twice a month	131	31.05	388.47	22.83	100.70
	Never or almost never	255	67.93	355.78	10.31	110.22
Look up ideas and information	Once or twice a week	111	15.03	360.38	130.71	111.30
	Once or twice a month	228	51.32	374.74	15.56	106.19
	Never or almost never	113	33.65	360.66	19.77	112.79
Do scientific procedures or experiments	Once or twice a week	38	0.47	540.34	11.94	68.96
	Once or twice a month	102	22.48	402.02	38.78	94.47
	Never or almost never	312	77.05	356.81	9.05	110.86
Study natural phenomena through simulations	Once or twice a week	118	25.25	360.16	15.29	102.70
	Once or twice a month	116	22.67	402.90	38.62	94.94
	Never or almost never	218	52.09	356.31	13.05	115.21
Process and analyse data	Once or twice a week	38	0.47	540.34	11.94	68.96
	Once or twice a month	116	22.67	402.90	38.62	94.94
	Never or almost never	298	76.86	356.44	9.07	110.65

Practice skills and procedures

Among the students taught by teachers who indicated that they use computers during Science lessons, 255 students out of 452 were taught by teachers who 'never or almost never' 'Practice skills and procedures' in computers. The results also shows that those students who used computers to 'practise skills and procedures' during science lessons 'once or twice a week' performed better than those who use computers 'once or twice a month' and those who 'never or almost never' use computers.

Look up ideas and information

On 'looking up ideas and information' construct during Science lessons using computers, the majority of the students, 228 out of 452, were taught by teachers who said they use computers for this construct 'once or twice a month'. The same group of students performed better than those who used the computer 'once or twice a week' and those who 'never or almost never' use the computer for the construct.

Doing scientific procedures or experiments

The majority of the students, 312 out of 452, were taught by teachers who said they 'never or almost never' use computers to search for scientific procedures or experiments and this group performed the least than those students who were taught by teachers who used the computers for the construct 'once or twice a month' and 'once or twice a week'.

Studying natural phenomena through simulations

About half of the students were taught by teachers who ‘never or almost never’ use computers to study natural phenomena through simulations and this group of students performed the least as compared to those who were taught by teachers who used the computers for such once or twice a month and a week. Those who were taught by teachers who used the computer ‘once or twice a month’ performed the best with an average score of 402 compared to 360 for ‘once or twice a week’ and 356 for ‘never or almost never’.

Processing and analysing data

The majority of the students, 298 out of 452, were taught by teachers who said they ‘never or almost never, use computers to process and analyse data. The cohort which was taught by teachers who processed and analysed data ‘once or twice a month’ performed the best.

Using of computers during mathematics lessons

Mathematics teachers were asked on whether there are computers available to be used by learners during Mathematics lessons. Their responses are related to students’ performance in Table 8.17.

Table 8.17: *Use of Computers during Mathematics Lessons and Students Performance*

	n	%	Mean	SE	SD
Yes	438	7.55	375.38	6.05	79.63
No	4,975	92.45	392.73	2.44	83.30

The majority of the centres in the study indicated that they do not use computers during Mathematics lessons, as about 92% of students were taught by teachers who indicated that, they do not use computers during Mathematics lessons.

Students’ access to computers during Mathematics lessons

The teachers were asked to indicate whether their students share computers or not or use computers sometimes during Mathematics lessons. The results are presented in table 8.18.

Table 8.18: *Students Access to Computers during Mathematics Lessons and Students’ Performance*

		n	%	Mean	SE	SD
Each student has a computer	No	438	100.00	375.38	6.05	79.63
Student sharing computers in class	Yes	42	5.48	362.67	5.44	78.35
	No	396	94.52	376.11	6.27	79.62
School has computers used sometimes	Yes	438	100.00	375.38	6.05	79.63

In Mathematics, almost all students were taught by teachers who indicated that their students share computers and also all teachers indicated that their students use computers sometimes.

Activities done on computers during Mathematics lessons

Mathematics teachers were asked to show whether their students use the computers to '-Explore Mathematics principles and concepts, Practice skills and procedures, look up ideas and information and process and analyse data. The results are indicated on Table 8.19.

Table 8.19: *Activities Done with Computers during Mathematics Lessons and Students' Performance*

		n	%	Mean	SE	SD
Explore Mathematics principles and concepts	Once or twice a week	45	12.97	393.69	5.15	76.72
	Once or twice a month	127	25.38	360.10	20.11	84.50
	Never or almost never	266	61.65	377.81	5.05	76.96
Practice skills and procedures	Once or twice a week	45	12.97	393.69	5.15	76.72
	Once or twice a month	131	31.96	368.24	11.12	79.34
	Never or almost never	262	55.07	375.20	7.91	79.70
Look up ideas and information	Once or twice a week	60	14.66	399.96	87.26	81.96
	Once or twice a month	147	36.07	372.86	12.63	79.95
	Never or almost never	190	49.27	376.62	5.20	75.36
Process and analyse data	Once or twice a week	45	12.97	393.69	5.15	76.72
	Once or twice a month	86	18.33	371.01	22.99	83.70
	Never or almost never	307	68.70	373.08	6.54	78.51

Exploring Mathematics principles and concepts

The same trend in Science manifest even in Mathematics, where the majority of the students (61.65%) were taught by teachers who indicated that, they 'never or almost never' used computers to explore mathematical principles and concepts. Thus the frequent use of computers facilitated students' performance to some extent, as such schools should be furnished with computers connected with internet.

Practising skills and procedures

The majority of the students, 262 out of 438, were taught by teachers who indicated that, they 'never or almost never' use computers to practice skills and procedures. The students (45) who were taught by teachers who indicated that they use computers 'once or twice a week' performed better than all the students.

Look up ideas and information

As in other activities listed above, most of the students were taught by teachers who said, they 'never or almost never' use computers to look up ideas and information in Mathematics. Where students use computers once or twice a week, the performance is better than in other groups of students.

Processing and analysing data

About three quarters of the students who were taught by teachers who said they 'never or almost never' use computers to process and analyse data in Mathematics. Students who had more exposure to computer usage performed better than those who had less exposure.

Computers in school

School Heads were asked to indicate the number of computers in their schools. The school heads were given a range of choices to choose from and the results are presented in Table 8.20.

Table 8.20: *Number of Computers in Schools and Students' Performance*

	No. of computers	n	%	Mean	SE	SD
Mathematics	0-10	1,038	20.35	392.59	83.79	2.50
	11-20	2,410	42.97	386.45	81.26	1.47
	21-30	1,102	18.60	394.21	81.32	3.26
	31-40	229	3.33	384.17	89.94	5.00
	41-50	146	2.71	400.79	80.86	5.71
	51+	782	12.04	402.49	88.17	3.14
Science	0-10	1,038	20.35	391.73	108.99	3.38
	11-20	2,410	42.97	387.00	105.70	1.94
	21-30	1,102	18.60	396.79	108.82	4.64
	31-40	229	3.33	385.55	120.30	8.70
	41-50	146	2.71	410.37	104.51	8.45
	51+	782	12.04	404.31	111.89	4.15

The majority of the students came from schools with 11-20 computers followed by those who came from schools with 0-10 and 21-30 computers. The results show a mixed association between increase in number of computers and the students' performance. The results shows that every centre has computers but the computers add no value in Mathematics and Science teachings. There should be a policy enforcing the use of computers in teaching.

Availability of Science Laboratories and Library in Schools

School heads were required to indicate whether their schools have functional Science laboratories and libraries. The results are as in shown in table 8.21.

Table 8.21: *Existing Number of Science Laboratories and Student Performance*

			Mathematics			Science		
	n	%	Mean	SE	SD	Mean	SE	SD
Yes	5,071	86.89	392.55		83.17	394.36		107.97
No	636	13.11	383.65		82.48	379.82		110.43

The majority of the students (about 87%) came from schools in which the schools had working laboratories. This group of students performed better than those from schools with no working laboratories.

Table 8.22: Availability of School Libraries

	n	%	Mathematics			Science		
			Mean	SE	SD	Mean	SE	SD
Yes	5,614	98.26	391.51		83.12	392.66		108.37
No	93	1.74	384.26		83.61	380.45		109.55

As shown from Table 8.22, almost all schools had a library as about 98% of the students came from schools with a library.

Inadequacy of resources and student performance

The school heads were asked to indicate the effectiveness of lack of resources in providing instruction in Mathematics and Science subjects by their teachers. The resources listed were lack of; specialised teachers of computer software/applications for instruction', relevant library resources', 'calculators' in Mathematics and Science, concrete objects or materials to help students understand quantities or procedures in Mathematics, and equipment and materials for Science experiments. An index was made where all these constructs were grouped to one as a problem in schools and then related to students' performance as shown in Table 8.23.

Table 8.23: *Inadequacy of Resources and Students' Performance*

		N	%	Mean	SE	SD
Science	Not a problem	1,436	14.97	432.85	7.93	107.31
	Moderate problem	2,634	51.48	388.91	4.48	107.94
	Serious problem	1,602	33.55	385.63	5.76	104.31
Mathematics	Not a problem	1,276	17.53	411.32	6.22	86.76
	Moderate problem	2,652	50.81	391.83	3.33	82.87
	Serious problem	1,570	31.65	379.15	4.60	80.21

The majority of the students were from schools where their School Heads indicated that they have a moderate problem in the listed resources. About 33% of the students came from schools where these resources were a serious problem in Science. The results also show that where there is no lack of resources the better the students' performance. Therefore, for fair delivery of the content in all schools, resources ought to be distributed evenly in all schools in the country, regardless of the location.

Teaching Science to the TIMSS class students

The Mathematics and Science teachers were asked to indicate to what extent the following limit how they teach their classes and how these factors related to students' performance. These are: students lacking prerequisite knowledge or skills, students suffering from lack of basic nutrition, students suffering from not enough sleep, disruptive students, uninterested students, students with physical disabilities and students with mental, emotional or psychological disabilities. Based on the fact that these factors can negatively impact the teaching of the Mathematics and Science subjects, an index was made where they were grouped into one factor as shown in Table 8.24.

Table 8.24: *Students' Limitations to Teaching and their Performance*

Subject	Category	n	%	Mean	SE	SD
Mathematics	Not Limited	897	13.98	398.11	7.35	86.66
	Somewhat Limited	3,854	71.93	392.29	2.60	82.70
	Very Limited	664	14.09	380.29	7.91	82.66
Science	Not Limited	833	11.49	412.93	12.07	115.64
	Somewhat Limited	4,380	79.37	392.32	3.41	107.21
	Very Limited	468	9.13	382.27	8.36	103.44

The majority of the students (about 72%) were taught Mathematics by teachers who indicated that students' limitations somewhat affect their performance. The students who were taught Mathematics by teachers who said their students had no limitations in learning performed the best, while those students with high limitations performed the least.

As in Mathematics, the majority of the students (about 79%) were taught Science by teachers who said they had a limitation in their teachings due to students' misfortunes. Where the teachers indicated that their teachings are not limited by these factors, their students performed best in Science.

Therefore, teachers ought to be trained on how to deal with any form of circumstances they face in their classroom teachings.

Frequency of engaging students with homework

Mathematics and Science teachers were asked to indicate how often they engage their students in doing homework and also how much time in minutes do they assign their students to work on their homework. The teachers were also asked on how often they; correct assignments and give feedback to students, have students correct their own homework, discuss the homework in class and monitor whether or not the homework was completed. The teachers' responses are related to students' performance in Table 8.25.

Table 8.25: *Homework/Assignments and Overall Students' Performance in Science*

Homework Assignment	Frequency of Homework	n	%	Mean	SE	SD
How often do you assign homework to the students?	No science homework	177	3.99	378.66	22.30	110.04
	Less than once a week	1,031	18.58	396.99	10.40	107.63
	1 or 2 times a week	3,678	69.05	397.01	3.81	107.85
	3 or 4 times a week	344	6.91	372.40	8.36	103.73
	Every day	131	1.47	377.56	45.75	136.92
How many minutes do you usually assign homework	15 minutes or less	1,489	29.38	397.96	6.42	108.15
	16–30 minutes	2,915	55.08	392.46	4.25	108.49
	31–60 minutes	689	12.13	392.51	9.00	109.96
	61–90 minutes	131	1.92	415.19	16.50	92.05
	More than 90 minutes	104	1.48	385.13	42.95	103.77
Correct assignments and give feedback to students	Always or almost always	4,259	80.19	391.95	3.14	107.74
	Sometimes	1,126	19.81	404.09	6.74	109.56
Have students correct their own homework	Always or almost always	1,855	36.08	397.00	6.25	110.81
	Sometimes	2,522	49.26	394.25	4.55	106.63
	Never or almost never	935	14.67	388.48	8.79	107.44
Discuss the homework in class	Always or almost always	3,885	71.14	394.72	3.83	108.79
	Sometimes	1,297	27.09	393.78	6.51	107.47
	Never or almost never	99	1.77	390.31	30.62	104.85
Monitor whether or not the homework was completed	Always or almost always	4,640	89.03	394.89	3.07	108.00
	Sometimes	604	9.57	389.26	11.97	109.65
	Never or almost never	68	1.40	398.25	68.10	117.33

There are still few teachers who give no assignments to the students (3.99%). Also, there are a few who give their students (1.47%) homework everyday but the majority of the students (about 88%) were taught Science by teachers who said they gave their students homework less than once a week and 1 or 2 times a week. The students who were taught Science by teachers who gave their students homework less than once a week and 1 or 2 times a week performed better than where the teachers gave their students homework more frequently or not at all.

The students, even though few in number, taught by teachers who said they assigned more than 90 minutes for their students to do assignments performed the least, as compared to those whose teachers said they give either 15 or 15 – 30 or 30 – 60 or 30 – 90 minutes.

The majority of the students (80%) were taught by teachers who correct assignments and give feedback to students always or almost always. On the set of questions asked, having students correcting their assignments has a distinctive output as the students (49%) taught by teachers who indicated that, they give this ‘always or almost always’ performed better than those of ‘sometimes or never or almost never’. The mean of this group of students is 397.00, while for sometimes and never or almost never are 394.25 and 388.48, respectively. Discussing the homework in class does not have much impact on the performance of the students as the mean marks are almost comparable, while monitoring whether the assignments are completed or not showed mixed results.

Table 8.26: *Homework Assignments and Overall students’ Performance in Mathematics*

Frequency of Homework	n	%	Mean	SE	SD
Every day	2,818	49.02	386.94	2.71	82.80
3 or 4 times a week	1,695	28.12	405.16	3.08	79.67
1 or 2 times a week	803	13.35	390.70	4.44	82.92
Less than once a week	327	6.09	397.03	7.73	84.06
Never	184	3.42	385.04	8.01	77.80
No mathematics homework	297	5.68	310.21	5.91	77.88
1–15 minutes	1,266	22.97	378.65	3.29	84.75
16–30 minutes	1,972	34.46	407.94	2.60	78.25
31–60 minutes	1,199	20.46	416.44	3.12	72.79
61–90 minutes	376	6.71	402.17	5.35	75.26
More than 90 minutes	510	9.72	372.35	4.78	72.77

As indicated from Table 8.26, most of the students (77%) were taught Mathematics by teachers who said they give their students homework every day and 3 or 4 times a week. According to the results the most effective way of giving homework is 3 or 4 times a week, with a mean of 405.16. There are those teachers who indicated that they do not give their students Mathematics homework, and such students seem to have been at a disadvantage as they performed the least. Therefore, school management had to check whether their teachers give homework to the students on weekly basis.

As in Science, giving long assignments which students spend more than 90 minutes to do seem to bear no fruits as the group performed the least (372.35) together with those students whose teachers said they give no assignments (310.21). The most effective period of harnessing the best results is when assignments given take 16-30 minutes, 31-60 minutes and 61-90 minutes to complete by the students.

Student background

The students who took part in this study were asked to indicate how often they spoke English at their homes. Their responses were matched with their performance in Mathematics and in Science. The results are as shown in Table 8.27.

Table 8.27: *Speaking English at Home and Students' Performance*

Category	n	%	Mathematics		Science	
			Mean	SE	Mean	SE
Always	408	5.07	382.95	110.48	385.51	140.33
Almost always	589	7.55	423.58	102.23	432.59	130.77
Sometimes	4,416	78.66	392.20	77.11	395.35	99.79
Never	506	8.72	361.16	86.42	337.68	114.80

The language for testing in this study is English, and the more the students speak the language at their homes the better the performance in Science and Mathematics. The majority of the students (about 79%) indicated that they speak English 'sometimes' at their homes. Therefore, parents ought to encourage their children to speak English at homes.

CHAPTER NINE: SCHOOL ENVIRONMENT

Introduction

School environment in this study refers to factors within and outside the school that make it safe for students to learn comfortably and with ease. These are factors that deal with issues concerning school enrolment, neighbourhood, safety, bullying, problems faced by students, and emphasis on academic success, among other issues that relate to the physical environment of schools. World Health Organisation (WHO) defines the physical school environment to encompass the school building and all its contents including physical structures, infrastructure, furniture, and the use and presence of chemicals and biological agents; the site on which a school is located; and the surrounding environment including the air, water, and materials with which children may come into contact, as well as nearby land uses, roadways and other hazards.

Eleven (11) items were identified to load on this theme. The majority of them (8) were from the School Questionnaire while two were from the Teacher Questionnaire and one from the Student Questionnaire.

Performance by School Size / Enrolment

School enrolment is a factor that has a bearing on learning. If the enrolment is more than what the resources can accommodate, this will have a negative impact on the performance of a school. “Smaller, more intimate learning communities consistently deliver better results in academics and discipline when compared to their larger counterparts. Big schools offer few opportunities to participate.” (*Washington Post as cited by Grauer & Ryan, 2016).*

Six groups of schools emerged when schools were categorised by enrolment. Performance by school enrolment is presented in Table 9.1. It emerged that the majority of the students (73.59%) attended schools with enrolment size ranging from 401 to 800 students. However enrolment seem not be linearly related to performance in both subjects.

Table 9.1: *Performance by school size/enrolment*

subject	Enrolment	n	%	Mean	SE	SD
Mathematics	less than 200 students	393	4.06	401.93	7.71	81.02
	201 to 400 students	737	8.04	381.13	10.58	90.10
	401 to 600 students	1 837	30.24	384.23	3.69	80.36
	601 to 800 students	2 110	43.35	399.14	3.79	83.80
	801 to 1000 students	317	8.21	387.96	5.93	81.27
	1001 to 1200 students	199	6.10	381.59	11.21	79.96
Science	less than 200 students	393	4.06	403.37	11.42	105.46
	201 to 400 students	737	8.04	378.33	14.12	117.05
	401 to 600 students	1 837	30.24	383.81	5.02	106.06
	601 to 800 students	2 110	43.35	402.62	4.76	108.24
	801 to 1000 students	317	8.21	386.34	7.75	107.28
	1001 to 1200 students	199	6.10	380.93	14.99	105.63

Analysis by school location revealed that the majority of the students (67.50%) attended schools in small villages and remote rural areas. Students in these schools performed the least (386.23 and 362.19 respectively in Mathematics and 386.01 and 353.37 respectively in Science) whilst those in high populated areas performed best as illustrated in Table 9.2.

Table 9.2: *Performance by School Location*

Subject	School location	n	%	Mean	SE	SD
Mathematics	Town/City	347	5.84	418.48	4.47	79.74
	Large Villages	756	12.34	408.25	7.10	80.28
	Medium size Village	801	14.31	418.49	6.33	82.74
	Small village	2 476	46.51	386.23	3.45	79.96
	Remote rural	1 245	20.99	362.19	3.86	81.86
Science	Town/City	347	5.84	430.34	6.12	97.84
	Large Villages	756	12.34	413.56	8.54	101.39
	Medium size Village	801	14.31	427.70	7.81	107.09
	Small village	2 476	46.51	386.01	4.17	104.06
	Remote rural	1 245	20.99	353.37	4.91	110.85

The low performance of students in the small villages and remote rural areas suggests that there should be more resources distributed towards areas populated with more students to promote better learning environments. Further analysis by cross tabulation of school location against school size revealed that there was no enrolment of 1 to 400 enrolment in urban densely populated centres. Performance was generally high in densely populated areas for both subjects and low for sparsely populated areas (Small Villages or Remote Rural areas) irrespective of the school population size.

Table 9.3: *Performance by School Enrolment and Location*

Subject	School location	Enrolment	n	%	Mean	SE	SD
Mathematics	Town/City	401 to 600 students	90	11.43	420.93	68.62	90.22
		601 to 800 students	173	45.55	432.71	10.09	80.85
		801 to 1000 students	44	21.75	398.27	6.07	75.26
		1001 to 1200 students	40	21.27	407.36	6.03	68.56
	Large Village	1 to 200 students	22	0.48	491.45	12.48	59.25
		201 to 400 students	136	7.03	430.98	70.40	94.95
		401 to 600 students	81	8.79	382.99	18.65	71.97
		601 to 800 students	482	83.70	409.05	8.25	79.50
	Medium size Village	1 to 200 students	63	1.25	535.33	12.36	54.29
		201 to 400 students	74	9.03	417.58	6.11	73.08
		401 to 600 students	89	7.10	437.74	34.32	71.48
		601 to 800 students	467	63.78	423.21	9.92	84.13
		801 to 1000 students	38	8.63	401.88	3.51	80.63
		1001 to 1200 students	35	10.22	400.03	6.43	76.04
	Small village	1 to 200 students	262	7.43	393.18	7.09	77.31
		201 to 400 students	343	8.59	367.89	16.36	88.14
		401 to 600 students	948	37.12	391.13	4.47	76.10
		601 to 800 students	606	30.98	386.82	5.69	78.61
		801 to 1000 students	149	8.36	389.20	13.19	83.95
		1001 to 1200 students	124	7.52	365.08	14.93	81.04
	Remote rural	1 to 200 students	46	1.90	408.11	7.99	64.54
		201 to 400 students	184	9.61	364.56	13.62	87.35
		401 to 600 students	592	46.61	361.74	4.62	83.20
		601 to 800 students	337	32.81	357.32	7.21	79.57
		801 to 1000 students	86	9.07	369.99	7.25	76.17
Science	Town/City	401 to 600 students	90	11.43	422.95	76.82	114.51
		601 to 800 students	173	45.55	445.87	11.24	99.83
		801 to 1000 students	44	21.75	408.11	7.45	88.73
		1001 to 1200 students	40	21.27	423.79	5.59	85.74
	Large Village	1 to 200 students	22	0.48	504.39	18.86	68.71
		201 to 400 students	136	7.03	437.46	75.39	106.22
		401 to 600 students	81	8.79	390.02	21.19	95.06
		601 to 800 students	482	83.70	413.82	10.12	101.65
	Medium Size Village	1 to 200 students	63	1.25	557.19	16.68	57.40
		201 to 400 students	74	9.03	426.19	6.66	91.90

	401 to 600 students	89	7.10	449.57	42.29	92.87
	601 to 800 students	467	63.78	434.21	12.02	107.58
	801 to 1000 students	38	8.63	397.83	6.58	116.79
	1001 to 1200 students	35	10.22	413.70	7.43	101.16
Small village	1 to 200 students	262	7.43	393.04	11.63	102.92
	201 to 400 students	343	8.59	362.37	21.82	117.96
	401 to 600 students	948	37.12	394.42	5.77	98.88
	601 to 800 students	606	30.98	387.15	6.96	101.13
	801 to 1000 students	149	8.36	387.18	17.57	109.04
	1001 to 1200 students	124	7.52	352.64	13.96	104.77
Remote rural	1 to 200 students	46	1.90	412.99	7.79	85.67
	201 to 400 students	184	9.61	356.38	19.61	116.60
	401 to 600 students	592	46.61	351.65	6.15	112.57
	601 to 800 students	337	32.81	348.79	8.01	108.55
	801 to 1000 students	86	9.07	363.04	10.50	103.66

Performance by Frequency of Bullying

One of the factors of school environment that affects learning is bullying. According to the literature, bullying is an old phenomenon and many parents have experience of it from their school days (Olweus, 1994). Bullies are usually children who have experienced some form of bullying themselves. They behave aggressively in an attempt to retaliate. They are children who feel powerless and suffer from low self-esteem. It should be emphasized that children who are bullied suffer terribly. School Heads were asked to indicate the extent to which bullying was prevalent in their schools. Figure 9.1 shows the different items that were loading in the ''bullying construct''.

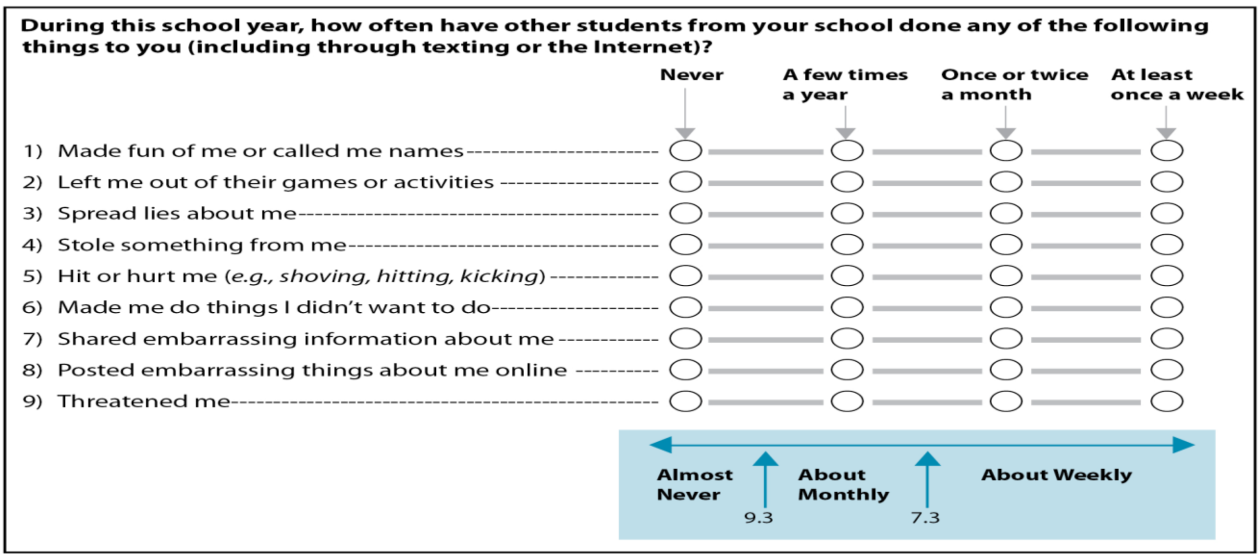


Figure 9.1: *Items Loading into the Bullying Construct*

Students' performance by frequency of bullying is presented in Table 9.4. It can be observed that bullying is increasingly invading the schools. For example, about 51% of the students were attending schools where they were bullied on monthly basis compared to about 19% in the previous TIMSS cycle of 2011.

Table 9.4: *Performance by Frequency of Bullying*

Subject	Frequency	n	%	Mean	SE	SD
Mathematics	Almost Never	1 508	25.57	408.48	2.69	71.59
	About Monthly	2 961	51.32	400.18	2.09	77.46
	About Weekly	1 289	23.11	368.35	4.33	92.01
Science	Almost Never	1 508	25.57	417.28	3.69	87.39
	About Monthly	2 961	51.32	405.70	2.68	100.53
	About Weekly	1 289	23.11	353.09	4.97	124.98

However, bullying is negatively correlated with students' performance. Students who were *Almost Never* bullied performed the highest in Mathematics (408.48) and Science (417.28) while those who were bullied often performed the least. This is consistent with the international situation where students who had Al*most Never* been bullied performed better (See Figure 9.2).

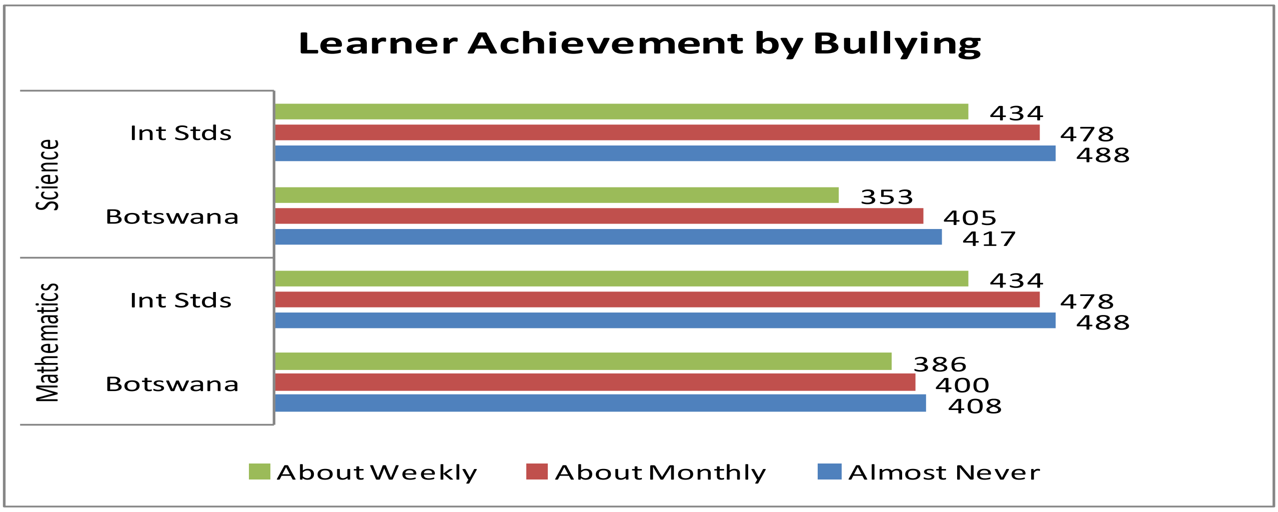
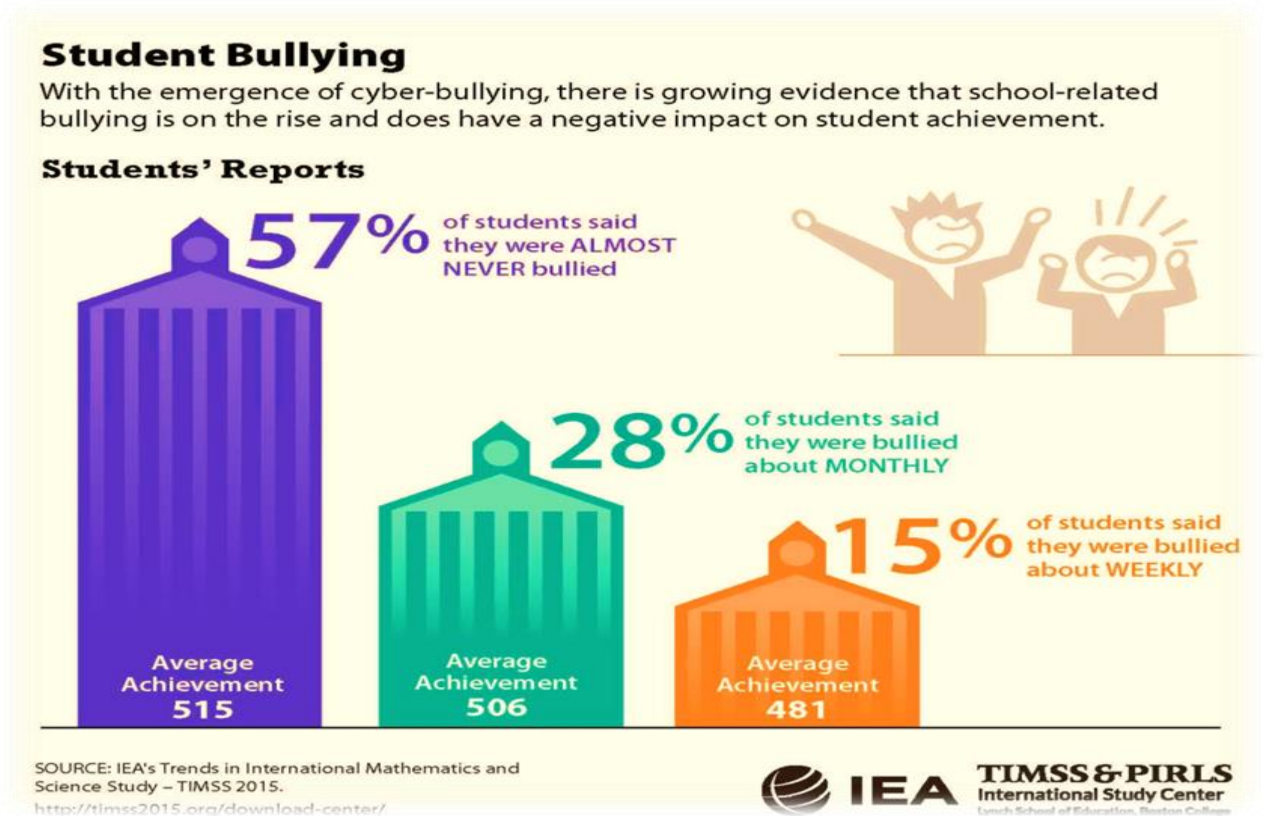


Figure 9.2: *International Students' Performance by Bullying Compared to Botswana*

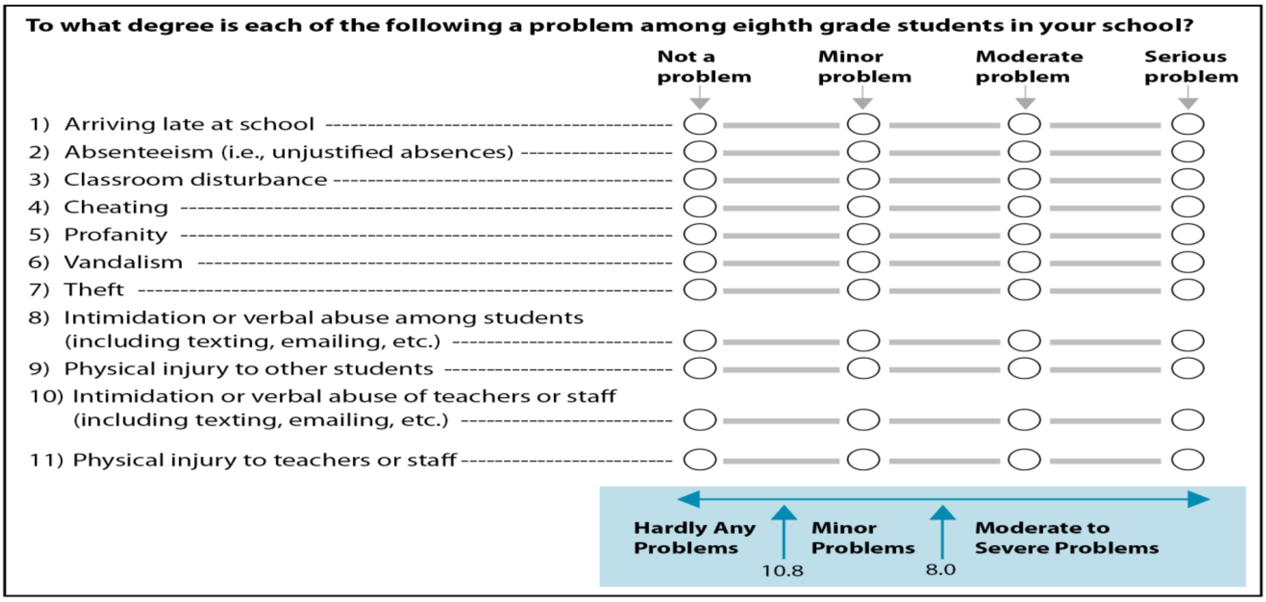
Bullying is more prevalent in Botswana than it is internationally. For example, Figure 9.3 shows that only 15% of international students reported that they were frequently bullied compared to 23% of Botswana students. The rise in bullying could be linked to the increase in computer technology advancement as another form of bullying (Cyber bullying) has emerged.



Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015
Figure 9.3: *Effects of Bullying Internationally*

Performance by School Discipline

Discipline forms part of an organised and functional progressive workforce and great organisations. Well-disciplined people in an organisation create an environment which is conducive for consistently carrying out activities or tasks that enable it to achieve its goals. Training in whatever capacity teaches one self-control, character, orderliness of efficiency thus portraying the purpose of discipline as being to regulate ones behaviour so as to direct it towards achieving the best for the individual, therefore it is a formal managerial control device (Cole, 2002). The School Head completed a questionnaire which sought among other things to find out about the students discipline. Students indiscipline included a number of aspects such as: arriving late at school; absenteeism (i.e., unjustified absences); classroom disturbance; cheating; profanity; vandalism; theft; intimidation or verbal abuse among students (including texting, emailing, among others); physical injury to other students; intimidation or verbal abuse of teachers or staff (including texting, emailing, etc.); and physical injury to teachers or staff, as depicted in Figure 9.4.



Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015

Figure 9.4: *Questions Used for the Indiscipline Part of the Questionnaire*

Although there was an impressive level of discipline, it must be noted that indiscipline is slowly encroaching in schools. Figure 9.5 shows that about 22% of Botswana students were attending schools where indiscipline was a major problem compared to 11% internationally. The remaining 78% were attending schools where it was a minor problem to non-existence compared to 89% internationally.

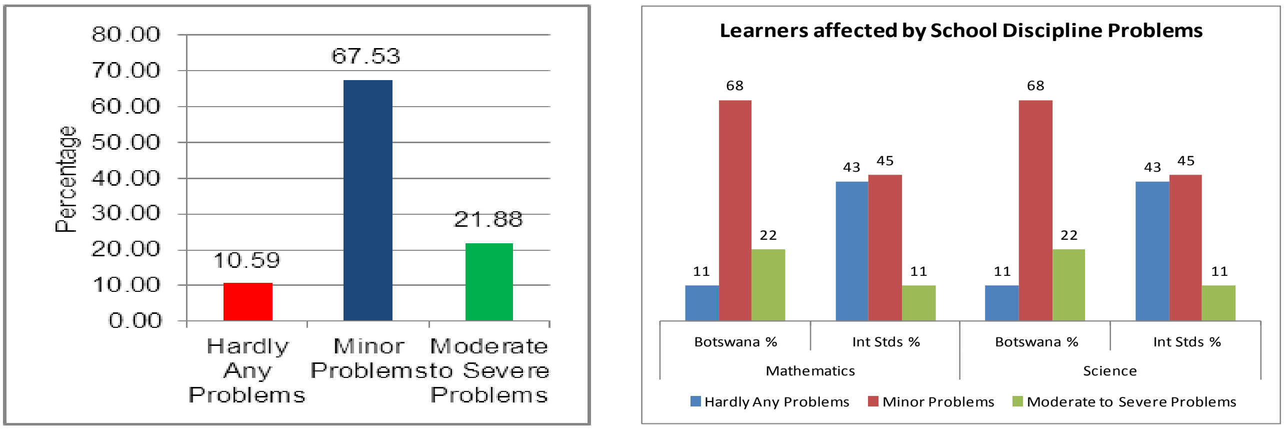


Figure 9.5: Extent of *Indiscipline in Schools*

Just like bullying, indiscipline negatively correlated with students' performance. Students attending schools where indiscipline was more prevalent performed lower in both subjects than students attending schools where indiscipline was minor as shown in Figure 9.6.

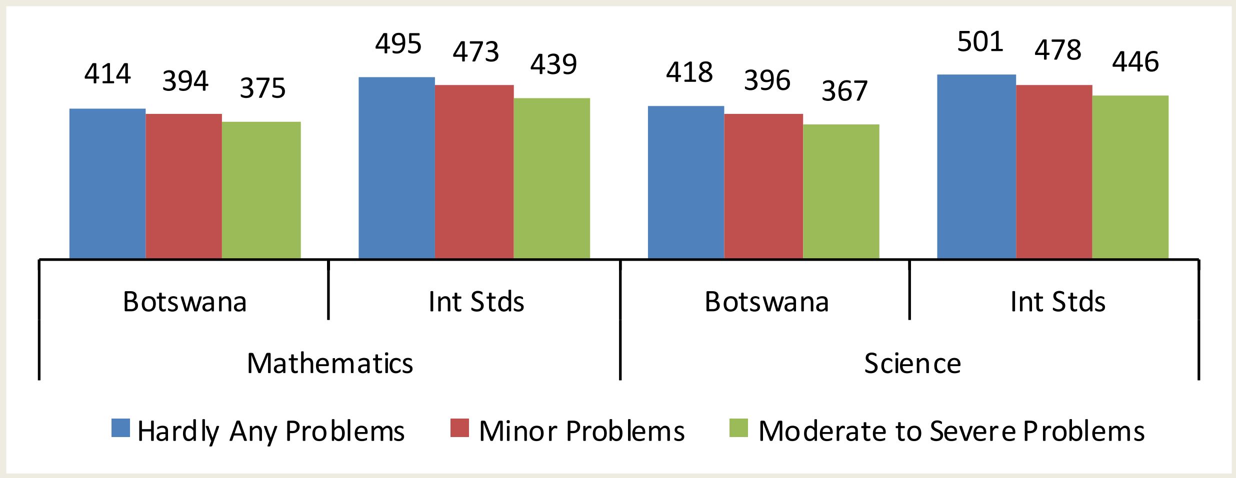
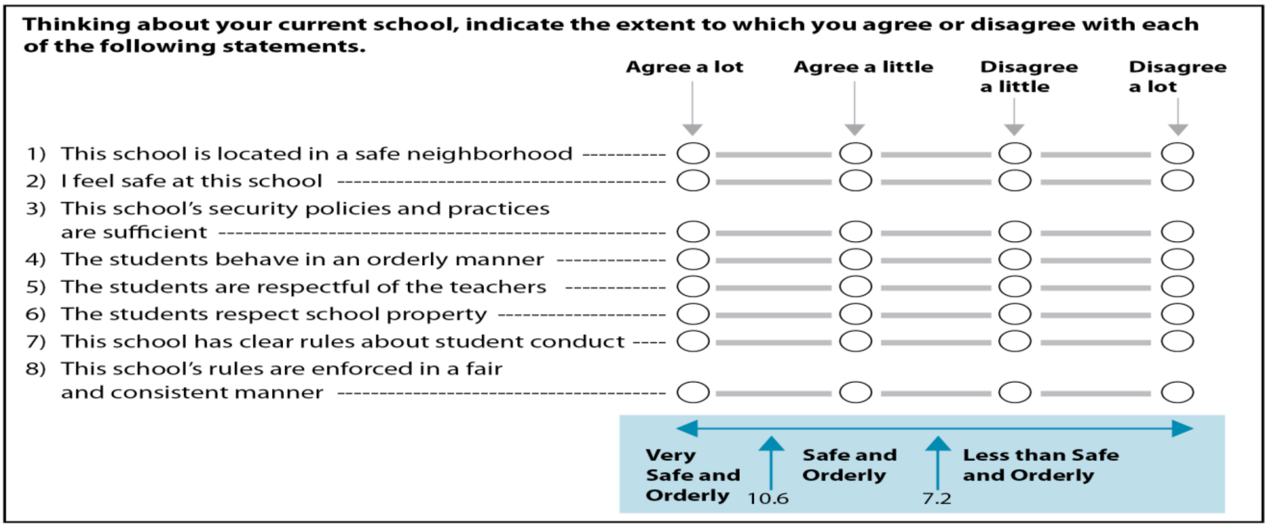


Figure 9.6: Performance *by Extent of Indiscipline in Botswana Schools and Internationally*

Performance by School Safety and Orderliness

Since there are many variables that are at play when you consider the performance of a school, safety and order are some of such fundamental aspects. Safety ensures that activities are carried out in an accident free environment hence allowing creativity to be at its optimum while order allows arrangement of things and their relationships to be observed at all-time thus achieving set out goals or objectives with minimal hindrance. Order also brings about a way of easily predicting future decisions or outcomes as a result of clear patterns or behavioural patterns. The School Head was asked to indicate the degree of safety and orderliness in the school. Items that loaded into this construct are presented in Figure 9.7. Based on the responses, an index was formed to generate three categories, being very safe and orderly (at least 10.6), safe and orderly (between 7.2 and 10.6) and less than safe and orderly (less than 7.2).



Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015

Figure 9.7: *Items for Safety and Orderly Construct*

The degree of 'Safety and orderly' was related to performance as presented in Table 9.5. Quite a sizeable number of students (32.02% for Mathematics and 30.35% for Science) were attending schools which were not safe and orderly. Comparatively, Botswana schools were not safe and orderly. While 92% of international students were attending schools that were at least safe and orderly, only 69% of Botswana students were. (See Figure 9.8).

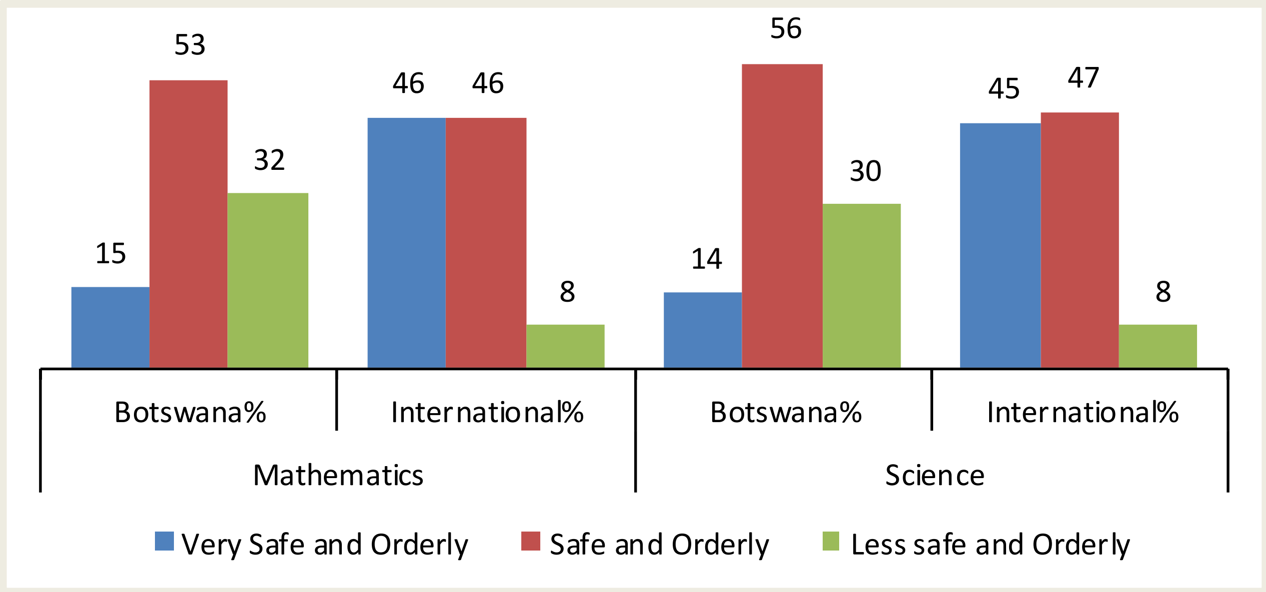


Figure 9.8: *Levels of Safety and Order in Botswana Schools Compared to International Standards*

Relatively high performance in Mathematics (414.55) and Science (426.26) was achieved by students in *very safe and orderly schools.*

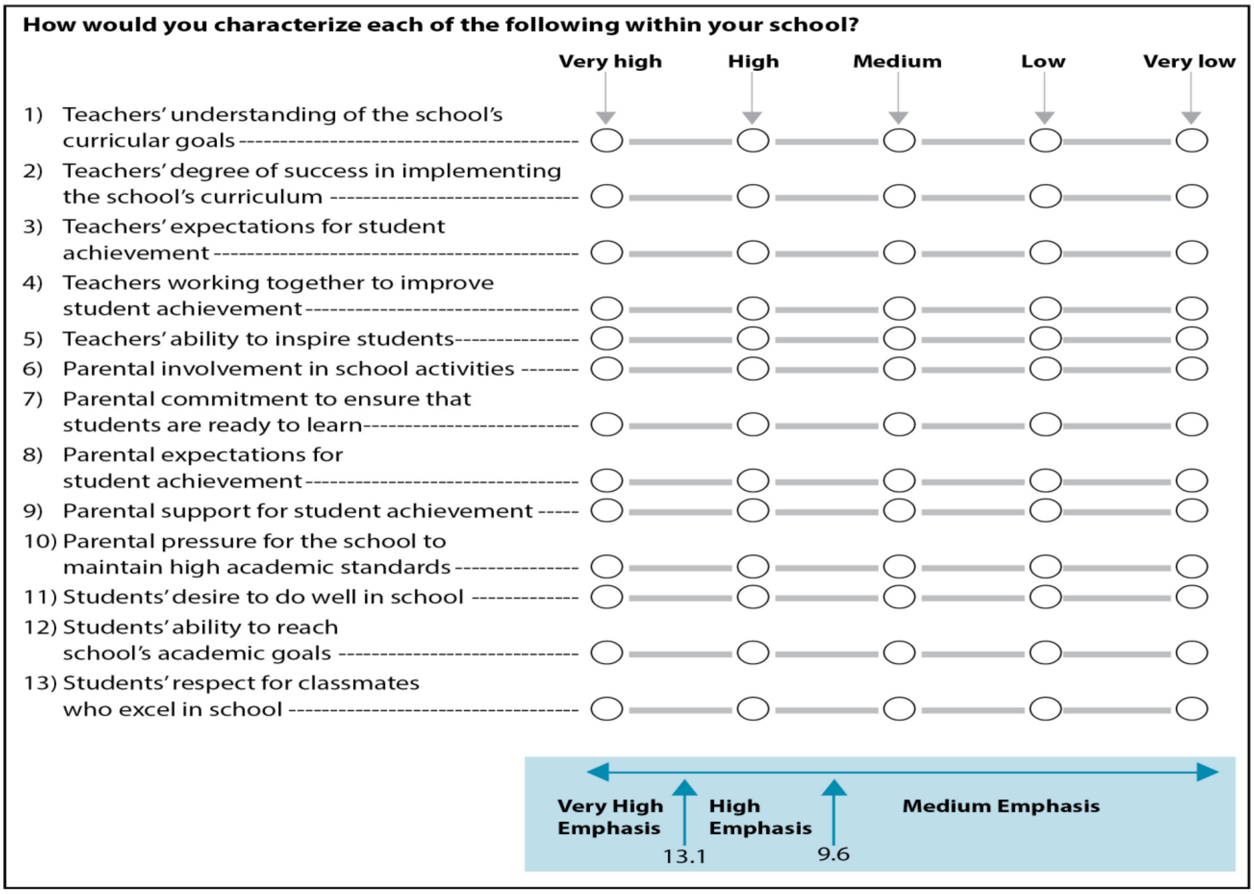
Table 9.5: *Performance of School by Degree of Safety and Orderly*

Subject	Degree of safety & order	n	%	Mean	SE	SD
Mathematics	Very Safe and Orderly	1 006	15.28	414.55	8.65	90.53
	Safe and Orderly	2 959	52.70	388.68	3.40	81.48
	Less than Safe and Orderly	1 580	32.02	384.51	3.66	80.61
Science	Very Safe and Orderly	1 039	13.56	426.26	10.25	110.68
	Safe and Orderly	3 156	56.09	387.08	4.05	107.50
	Less than Safe and Orderly	1 477	30.35	393.67	6.33	104.65

Safety and orderly is also positively associated with performance. The more safe and orderly the schools were, the higher the students' performance, as depicted in Table 9.5, of course with international students scoring higher than Botswana's.

School Emphasis on Academic Success

Academic success is achieved through consistently making awareness to stakeholders on the importance of key things that bring about the intended goals or objectives. In that light, School Heads were asked about issues on academics such as understanding the curriculum by teachers and knowledge of implementing it; teamwork; parental involvement in students learning; and student's expectations to achieve. Figure 9.9 below shows the different items forming the emphasis on academics which the teachers were asked. Based on the responses, an index was formed to generate three categories of *very high emphasis* (at least 13.1), *high emphasis* (between 9.6 and 13.1) and *medium emphasis* (less than 9.6).


How would you characterize each of the following within your school?

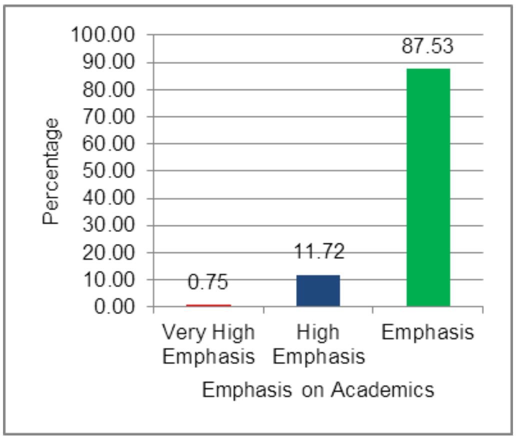
	Very high	High	Medium	Low	Very low
1) Teachers' understanding of the school's curricular goals	○	○	○	○	○
2) Teachers' degree of success in implementing the school's curriculum	○	○	○	○	○
3) Teachers' expectations for student achievement	○	○	○	○	○
4) Teachers working together to improve student achievement	○	○	○	○	○
5) Teachers' ability to inspire students	○	○	○	○	○
6) Parental involvement in school activities	○	○	○	○	○
7) Parental commitment to ensure that students are ready to learn	○	○	○	○	○
8) Parental expectations for student achievement	○	○	○	○	○
9) Parental support for student achievement	○	○	○	○	○
10) Parental pressure for the school to maintain high academic standards	○	○	○	○	○
11) Students' desire to do well in school	○	○	○	○	○
12) Students' ability to reach school's academic goals	○	○	○	○	○
13) Students' respect for classmates who excel in school	○	○	○	○	○

Very High Emphasis | 13.1 | High Emphasis | 9.6 | Medium Emphasis

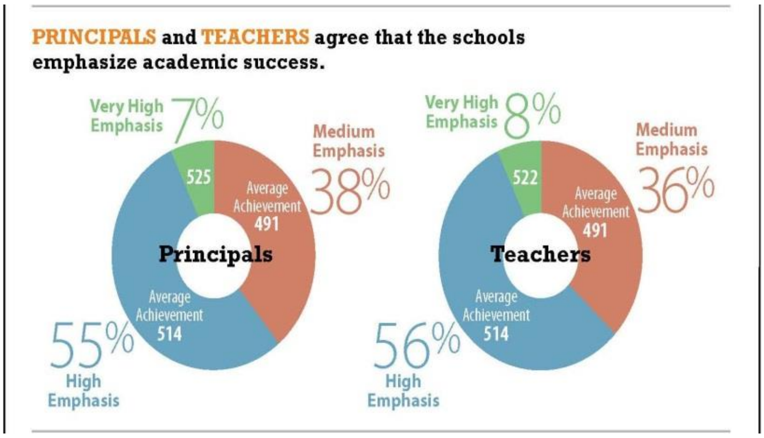
Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015

Figure 9.9: *Questions Used for Levels of Academic Emphasis by Schools in the Questionnaire*

It was found that the majority of students (87.53%) were attending schools that did not emphasise academics a lot, as shown in Figure 9.10. Botswana's emphasis on academics was negligible (.8%) as compared internationally (7% and 8% reported by teachers and school heads respectively).



(a) Botswana teachers



Source: IEA's Trends in International Mathematics and Science Study – TIMSS 2015

(b) International teachers

Figure 9.10: *Proportion of Students Attending Schools with Different Levels of Emphasis on Academics with Associated Performance for (a) Botswana Teachers and (b) International Teachers*

Emphasis on academics was also found to be positively correlated with performance. Students in schools emphasizing more on academics performed better in Mathematics and Science than those in schools emphasizing less for both Botswana and international students (See Figure 9.11).

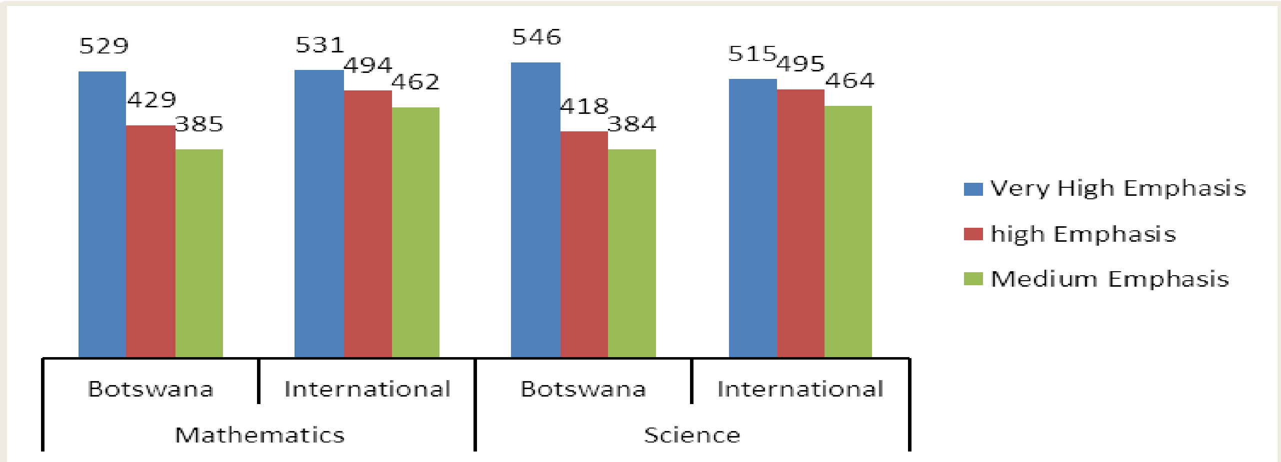


Figure 9.11: *Illustrations of Comparison in Students' Level of Performance in Emphasis on Academics for Botswana and International.*

CHAPTER TEN: PARENTAL INVOLVEMENT

Introduction

Parents play a critical role in the learning of their children. They provide learning opportunities from the time the child is born, all through their entire life. During their schooling days, children continue to learn at home. Therefore, it is apparent that there should be a strong link between the learning at school and the learning at home. By participating in and facilitating learning activities at home and at school, parents could create the link. Parents are therefore very important in their children's learning and performance. Parents play an important role in influencing the aspirations of their children. They should therefore have a constant and reciprocal partnership with their child's teachers and the school.

The most reliable predictor of a child's achievement in school is the extent to which that child's family is able to: create a home environment that encourages learning, express high expectations for their children's achievement and future career and become involved in their children's education at school and at home (Henderson & Berla, 1994). Parental involvement in the child education could be in the form of providing basic obligations like housing, frequently communicating with the school, participation in school activities, helping the child with homework and setting educational goals and participating in school committees (Epstein, 1995).

This chapter reports the relationship between parental involvement variable and performance of students in Mathematics and Science. The chapter analyses individual variables that speak to parents' background and parents' support activities. The variables were derived from all the questionnaires that were used to collect the data, namely; Parent, School, Student and Teacher questionnaires. Some individual variables that were identified to be addressing the same construct were however merged or put together to form an index.

Parents Background Variables

Parents' age

Parents or guardians were asked to indicate their age in the Parent Questionnaire. The results are indicated in Table 10.1. The majority of the students (37.87%) stayed with parents/guardians who were between the ages of 30 to 39, followed by those in the ages of range 40 to 49 with 34.34%. The least number of students (1%) stayed with parents/guardians who were under 20 years. Most of these under 20 years were relative guardians. These therefore could be siblings taking care of their young ones. It has been realised that there is a reduction of 1% of students who stayed with parents/guardians under the age of 20 years from TIMSS 2011, where it was 2%. Figure 10.1 below shows the differences.

Looking at the performance of students in Mathematics and Science, by the age categories, the results indicate that students who stayed with parents/guardians who were between the age of 40 – 49 performed best in both subjects. The second best performing group in both subjects were students whose parents/guardians were between the ages of 30 – 39. The least performing students in both Mathematics and Science were students whose parents/guardians indicated that they were under 20 year old. Generally, the results indicate that the older the parent/guardian, the higher the performance in both Mathematics and Science. However, the performance of students declined in both subjects when parents/guardians were 50 years or older.

Table 10.1: *Performance of Students by Parents' Age*

			Mathematics		Science	
Age categories	Number	%	Mean	SE	Mean	SE
Under 20	33	0.84	314.19	13.21	294.80	13.66
20–29	218	5.73	383.18	6.73	381.05	8.97
30–39	1,473	37.87	392.26	3.01	394.26	4.13
40–49	1,466	34.34	403.07	3.57	408.96	4.45
50 or older	863	21.22	390.70	4.17	392.03	4.72

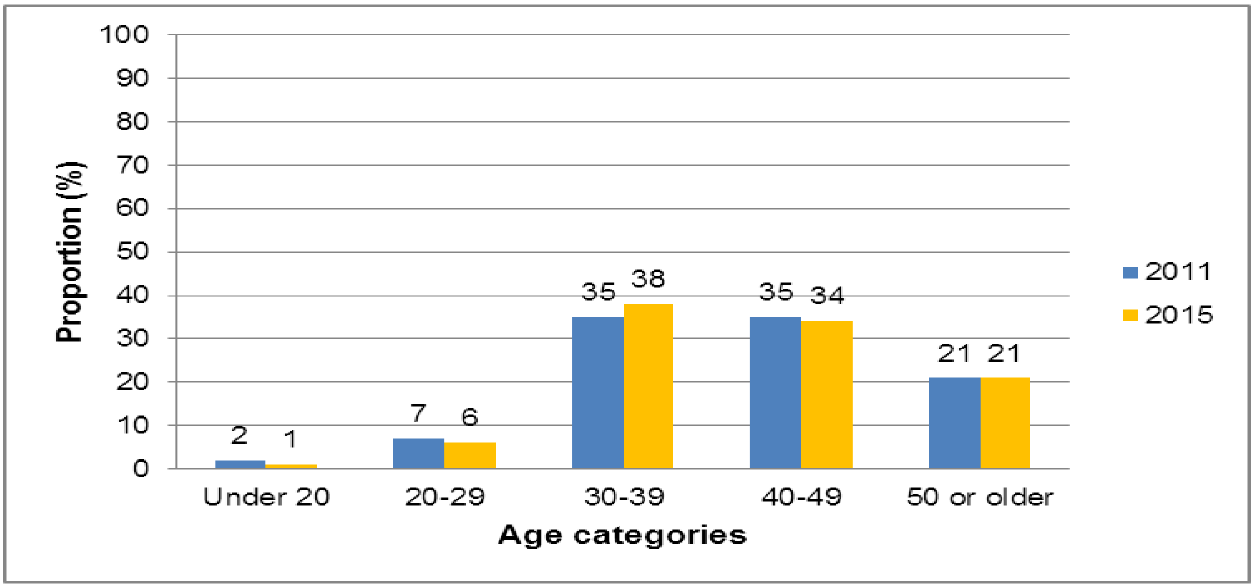


Figure 10.1*: Trend Proportion of Students by Parents' Age Grouping*

The results of cross tabulating parents/guardians' age with their marital status indicated that the least performing age groups had the highest proportion of single parents/guardians. The results are shown in figure 10.2.

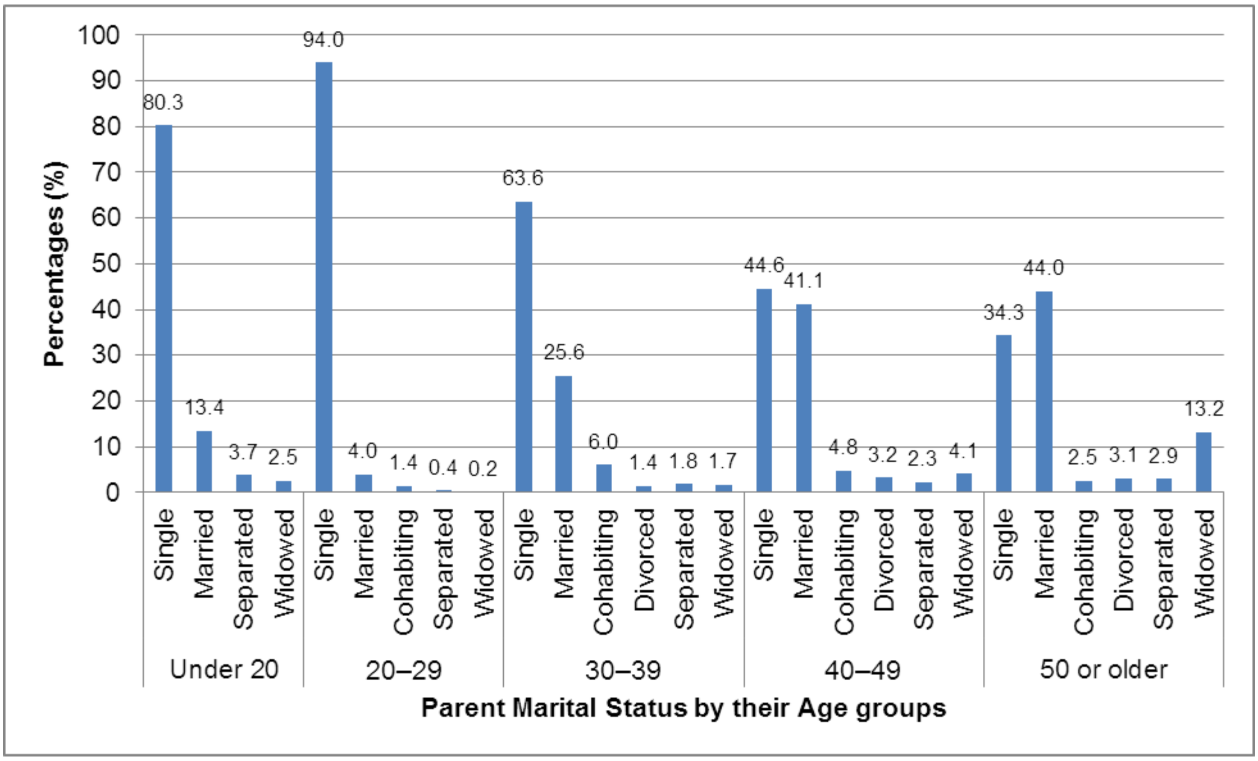


Figure 10.2: *Proportion of Students by Parents' Marital Status and Age Grouping*

Parents/guardians marital status

Parents or guardians were asked to indicate their marital status. It came out that most students (52.79%) stayed with single parents/guardians (Table10.2). The majority (67%) of the single parents/guardians were single mothers (Table 10.3). Figure 10.2 indicates that the single parents/guardians were dominant in the 20 - 29 age group with 94%, followed by the under 20 age group with 80.3%. The second largest group of students (33.44%) stayed with married parents/guardians. Figure 10.2 also shows that the married parents/guardians were dominant in the 50 or older age group with 44%, followed by the 40 – 49 age group with 41.1%. Focusing on all marital status categories where parents/guardians did not stay together, the results indicated that in all the categories, most of the time students stayed with their mothers. The results are shown on Table 10.3 below.

In terms of performance in Mathematics and Science, the results indicated that students who stayed with divorced parents/guardians performed best in both subjects, followed by students who stayed with married parents/guardians. One would have expected students who stayed with married parents/guardians to perform best, but students who stayed with divorced parents/guardian were maybe motivated by the situation they found themselves in. The difference between the two groups was not that much though.

The least performing group of students were students who stayed with parents/guardians on separation. This could be probably because of the tension that normally is created between the parents/guardians who are on separation. Generally the results indicated that in situations where parents are or were once married performance tended to be higher, except in cases where parents/guardians were on separation.

Table 10.2*: Performance of Students by Parents' Marital Status*

			Mathematics		Science	
Marital status	Number	%	Mean	SE	Mean	SE
Single	1,994	52.79	381.55	2.62	380.31	3.12
Married	1,489	33.44	412.53	3.77	421.79	4.77
Cohabiting	190	4.54	394.78	7.70	392.27	10.17
Divorced	101	2.26	421.94	10.75	427.30	14.18
Separated	83	2.12	376.33	9.00	374.78	12.97
Widowed	190	4.85	404.07	6.18	411.16	9.34

Table 10.3: *Proportion of Students by Marital Status by Relationship to the Student*

Marital status	Relationship to the child	Proportions
Single	Father	6.82
	Mother	66.85
	Relative guardian	25.56
	Non-relative guardian	0.76
Divorced	Father	21.60
	Mother	57.08
	Relative guardian	17.99
	Non-relative guardian	3.33
Separated	Father	19.42
	Mother	67.95
	Relative guardian	12.63
Widowed	Father	10.79
	Mother	60.80
	Relative guardian	28.41

Parent/guardian education level

The assumption that parents learn something during their schooling that influences the way they interact with their children around learning activities is the most prominent and direct explanation of the link between parents' level of education and their children's academic performance (Corwyn & Bradley, 2002; Davis-Kean, 2005). Parents help their children with homework and also discuss and set educational goals with their children. Parents/guardians were asked about the level of education they have achieved. And the results are shown in Table 10.4 below.

Most of the students (37.50%) stayed with parents/guardians who completed secondary education, followed by those who stayed with parents/guardians who have never attended school with 27.31%. The least proportion of students (12.96%) stayed with parents/guardians who completed post-secondary education.

The performance results generally indicate that the higher the education levels of the parent/guardian, the higher the performance of students in both Mathematics and Science.
Students whose parents/guardians completed post-secondary education performed higher in both Mathematics and Science. They were followed by students who stayed with parents/guardians who completed secondary education. The least performing group of students were those who stayed with parents/guardians who never attended school.

Table 10.4: *Performance of students by parents/guardians' highest education level*

			Mathematics		Science	
Level of education	n	%	Mean	SE	Mean	SE
Never attended school	947	27.31	366.00	3.06	359.83	4.19
Completed Primary Education	746	22.22	379.02	3.38	377.18	4.49
Completed Secondary Education	1,315	37.50	405.05	2.63	410.97	3.79
Completed Post-Secondary Education	603	12.96	448.18	4.41	470.36	5.96

Frequency of engaging the child on home chores

After school hours, students assist parents and other family members with the different home activities. This of course exposes them to another form of learning, other than the learning at school. Nonetheless, students need to continue with school work at home as well. The time for home activities and school activities at home therefore need to be balanced. Parents were asked to indicate how much they engaged students to help with home chores after school hours. Most students (64.13%) came from homes where they were sometimes engaged on home activities. The least proportion of students (10.33%) stayed with parents/guardians who engaged them regularly. The largest proportion of students who were engaged on home chores were those who the parents/guardians' main source of income was agriculture; 88% of the students whose parents/guardians' main source of income was 'Sale of livestock' were engaged on home chores, followed by 84% of those whose parents/guardians' main source of income was 'Sale of farm produce'. The least engaged proportion (69%) was for the students whose parents/guardians main source of income was 'Salary/wage' as shown in Figure 10.3.

Students who were engaged regularly on home chores performed the least in both Mathematics and Science. This probably means that their regular engagement left little or no time for them to do school work at home. The best performing group were students who were never engaged on home chores. The majority of them (31%) came from homes which had a salary/wage as their main source of income, as indicated on Figure 10.3.

Table 10.5: *Students Performance by Frequency of Engaging the Child to Help at Home*

Frequency of engagement	n	%	Mathematics Mean	SE	Science Mean	SE
Regularly	347	10.33	384.93	5.40	385.93	7.02
Sometimes	2,172	64.13	395.73	3.04	397.76	3.70
Not at all	890	25.55	408.70	3.89	415.38	4.83

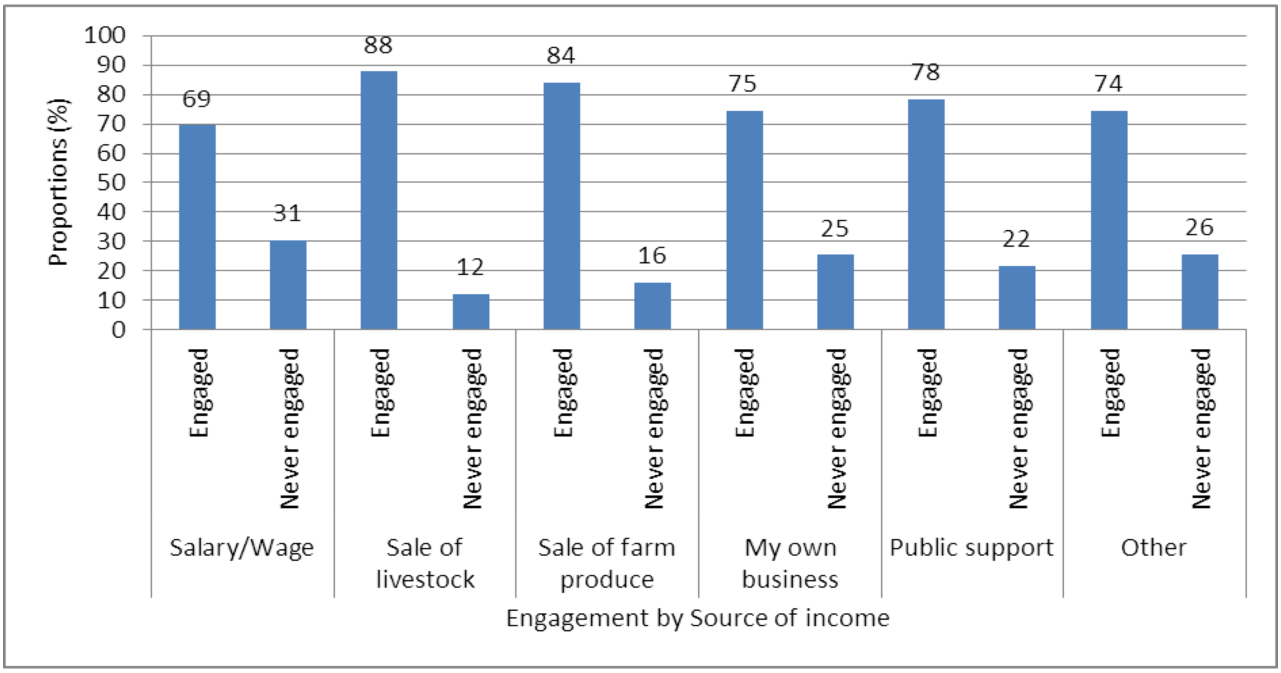


Figure 10.3: *Proportion of Students Engaged on Home Chores by Parents/Guardians' Main Source of Income*

Parent/guardian main source of income

Parents were asked about the source or origin of the income they bring to the house, to among other things support their children. Most students (46.03%) came from families or homes that had salary/wage/pension as their main source of income. The least proportion of students (5.66%) stayed with parents/guardians who sold farm produce to get income.

The performance of students from families that had salary/wage/pension as the main source of income was the best in both Mathematics and Science. This group was found out from Figure 10.3 above as being the least engaged on home chores. This could therefore mean that they had enough time to engage in their school work at home. The least performing group in both Mathematics and Science was students whom their families' main source of income was public support with mean of 362.58 and 353.07, followed closely from the bottom by the performance of students whose parents' main source of income was sale of livestock with a mean of 363.10 and 353.48, for Mathematics and Science respectively. It must be noted that from Figure 10.3 above, these two least performing groups had a high proportion of students who were engaged on home chores.

Table 10.6: *Performance of Students by Parents' Main Source of Income*

Main source of income	n	%	Mathematics		Science	
			Mean	SE	Mean	SE
Salary/Wage/Pension	1,728	46.03	416.07	3.04	425.59	4.16
Sale of livestock	331	9.24	363.10	5.20	353.48	7.12
Sale of farm produce	202	5.66	365.34	5.66	357.61	8.66
My own business	764	20.78	392.91	4.26	396.90	5.14
Public support	255	7.14	362.58	6.98	353.07	7.40
Other	391	11.15	382.52	4.91	380.46	4.94

Parent/guardian Socio-Economic Status (SES)

According to Lee & Bowen (2006), it is unfortunate that parents with low socioeconomic status (SES) are more likely to find it difficult to become and remain involved in their children's' education. SES is a measure of social positioning of a parent/guardian, in relation to others in terms of type of house, amenities in their compound, family assets, and household goods. Students and parents/guardians were asked several questions to determine their home possessions. The questions were put together to come up with an SES index. The questions established family possessions of amenities and household goods, which included refrigerator, running tap-water, electricity, telephone, flush toilet, radio, television, video, computer, motor vehicle, motor bike, bicycle, land, livestock, tractor, study desk, student's own room, internet connection, mobile phone and gaming system.

The results indicated that most of students (49.36%) came from homes with medium level of SES. The least proportion of students (22.21%) came from homes with low of SES. The performance results indicated that, generally the higher the level of SES the higher the performance in both Mathematics and Science. Students who came from home with high level of SES performed best in both subjects, with mean of 430.32 for Mathematics and 445.17 for Science. Students from low level of SES homes performed least in both Mathematics and Science, with mean of 366.66 and 358.84 respectively. The results are shown on Table 10.7.

Table 10.7: *Performance of Students by their Parents' Socioeconomic Status (SES)*

Level of SES	n	%	Mathematics		Science	
			Mean	SE	Mean	SE
High SES	1,264	28.43	430.32	3.63	445.17	4.17
Medium SES	1,769	49.36	394.90	2.56	397.44	3.23
Low SES	819	22.21	366.66	3.06	358.84	4.17

Number of digital devices at home

Digital devices are very crucial in students' learning in the 21st century. Students could use the devices in many educational activities. Students were asked to indicate the number of digital devices in their homes. The devices include smart phones, tablets, laptops, and computers. The majority of the students (43.84%) indicated that they had 1 to 3 digital devices at home. The least proportion (8.68%) of students said they had more than 10 digital devices at home. There was 17.92% of students who indicated that they had no digital devices at home.

In terms of performance, students who said there were 4 to 6 digital devices at home performed the best in both subjects. The least performing students were those that reported that there were no digital devices at their homes. The performance of students in both subjects generally increased or improved with the increase in the number of digital devices at home. But, after 4 to 6 digital devices, students' performance in both subjects started to decline. This could probably mean that when digital devices become abundant at home, students tend to use them otherwise, other than for educational purposes. The results are shown on Table 10.8.

Table 10.8: *Performance of Students by Number of Digital Devices at Students' Homes*

Number of digital devices	n	%	Mathematics		Science	
			Mean	SE	Mean	SE
None	977	17.92	366.19	3.60	356.59	4.58
1-3 devices	2,435	43.84	390.71	2.05	395.34	2.93
4-6 devices	1,243	20.37	411.07	2.97	416.17	3.87
7-10 devices	647	9.20	406.57	4.54	413.20	6.23
More than 10 devices	591	8.68	391.44	6.08	386.07	8.00

Parental Support Variables

Parent/guardian participation in school activities

Parents' participation in their children's home and school activities is very important. They actually start participating from the child's birth. Their participation must continue even during the child's schooling days. Parents and guardians were asked to indicate their participation in school activities concerning their child. The teachers were also asked to rate the participation of parents in the school activities. The results are shown on Tables 10.9 and 10.10. Most of students (54.32%) stayed with parents/guardians who said they sometimes participate in their child's school activities. About 13% of the students stayed with parents/guardians who said they did not attend their child's school activities. Most of the students in Mathematics (about 70%) came from schools where teachers reported that there was low participation in school activities by parents/guardians.

Very few students (about 7%) came from schools that reported high participation of parents/guardian in school activities. The teachers' report on parents/guardians participation has however indicated that there has been a reduction of about 2% in the proportion of students who came from schools where teachers reported low participation, as indicated in Figure 10.4. The results also indicate that the low participation of parents/guardian was dominant in government/public schools, as shown in Figure 10.5.

The results show that the higher the parents/guardian participation in their child's school activities, the higher the performance in both Mathematics and Science. On a similar note, students who attended schools where teachers reported high participation of parents/guardians performed best in both subjects. Students whose parents/guardians said they did not participate in their child's school activities performed least in both subjects. The same can be said about students who attended schools where teachers reported low participation of parents/guardians.

Table 10.9: *Performance of Students by Parent Participation in School Activities as Reported by Parents*

Participation			Mathematics		Science	
frequency	n	(%)	Mean	SE	Mean	SE
Regularly	1,364	33.00	400.11	3.20	404.98	4.30
Sometimes	2,165	54.32	394.14	2.76	397.02	3.27
Not at all	488	12.67	382.07	4.65	379.02	7.11

Table 10.10: *Performance of Students by Parent Participation in School Activities as Reported by Teachers*

Subject	Participation level	n	%	Mean	SE
Mathematics	High	542	6.76	422.63	10.22
	Medium	1,159	19.96	411.02	5.59
	Low	3,844	73.28	383.03	2.53
Science	High	719	7.55	438.75	17.91
	Medium	1,796	32.69	408.95	6.31
	Low	3,123	59.76	380.81	3.66

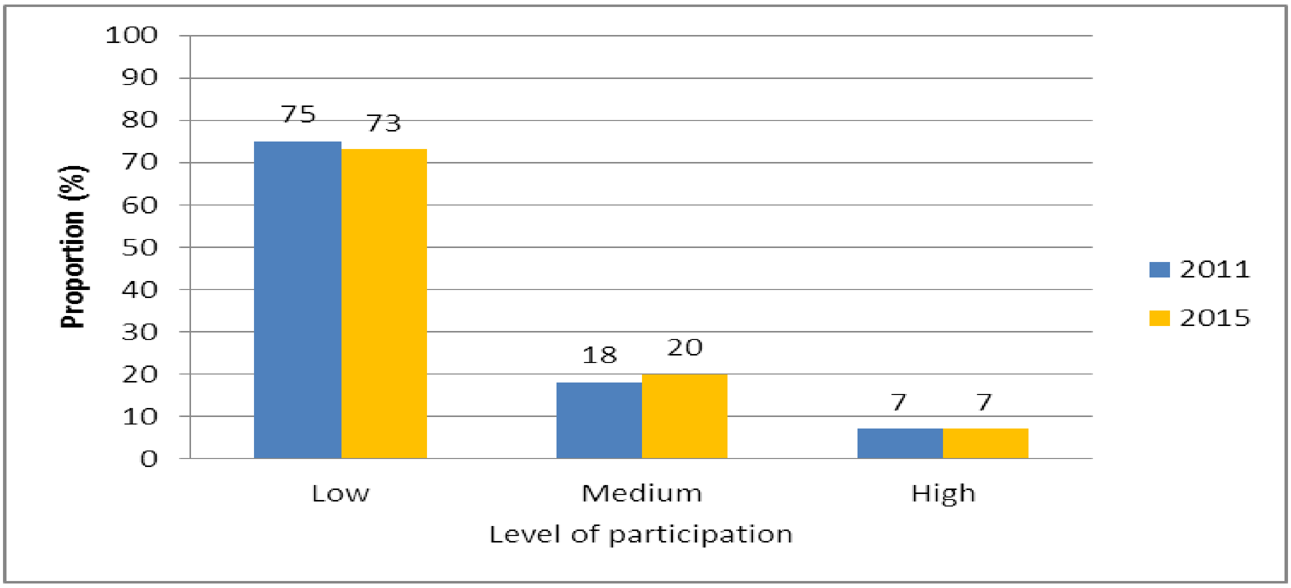


Figure 10.4*: Trend Proportions of Parents/Guardians' Participation in School Activities*

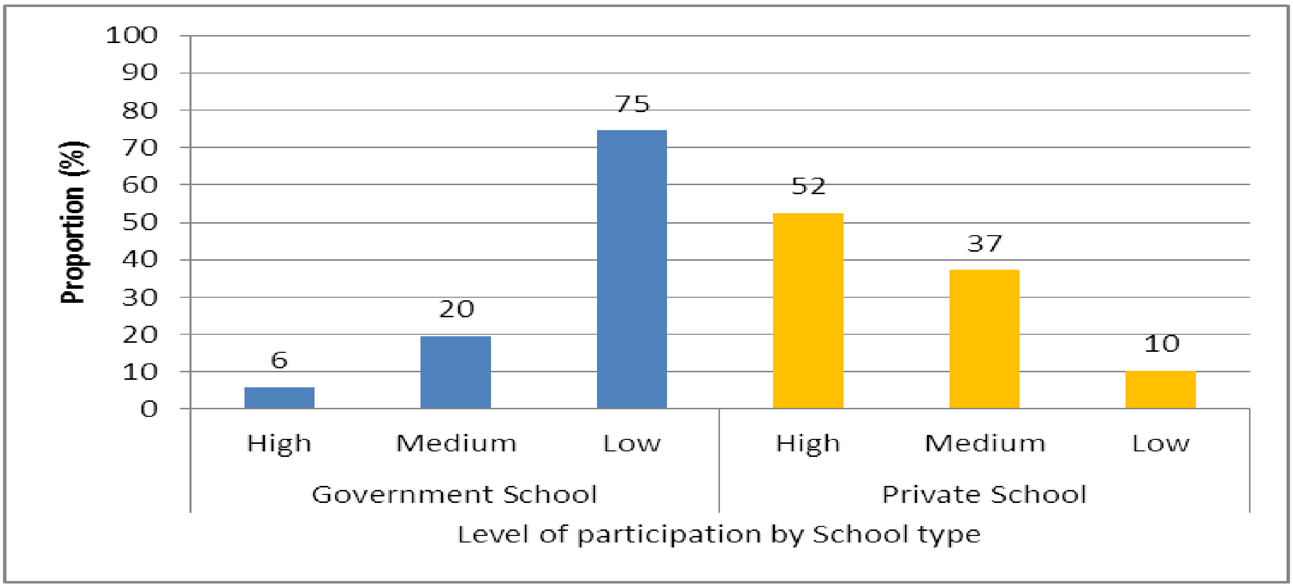


Figure 10.5*: Proportion of Students by Parents/Guardians' Participation in School Activities by School Type*

Parent/guardian support for child learning

Parents/guardians' participation in school activities gives an opportunity for a strong relationship between the child and the teacher. It lays a foundation for discussion of the child's school work with the teacher and the child. The relationship is very important, not only to the students' academic performance, but also to mould students' morale and attitude and promote better behaviour.

Parents/guardians were asked to indicate how often they discussed their child's school work with the child and the teacher. The results are shown in Tables 10.11 and 10.12. Most students (53.62%) stayed with parents/guardians who said they sometimes discuss their child's progress with the teacher. Only 14.48% of the students stayed with parents/guardians who said they regularly discuss their child's progress with the teacher. Surprisingly, about 32% of the students stayed with parents/guardians who indicated that they do not discuss their child's school work with the teacher.

Students whose parents/guardians indicated that they sometimes discuss their child's progress with the teacher performed best in both Mathematics and Science with the mean of 400.02 and 404.39 respectively. Students whose parents/guardians said they never discuss the child's school work with the teacher performed the least, with the mean of 383.59 in Mathematics and 383.71 in Science.

Table 10.11: *Performance of Students by Parent Discussion of Child's Progress with the Teacher*

Frequency of discussions	n	%	Mathematics		Science	
			Mean	SE	Mean	SE
Regularly	651	14.48	398.24	4.84	401.26	6.15
Sometimes	2,126	53.62	400.02	3.12	404.39	3.69
Not at all	1,205	31.90	383.59	3.27	383.71	4.50

The majority of the students (51.17%) stayed with parents/guardians who said that they sometimes discuss school work with their child. Very few students (9.50%) stayed with parents/guardians who indicated that they never discussed school work with their children.

The performance results indicate a positive relationship between the frequency of the discussions and the students' performance in Mathematics and Science. Students whose parents/guardians regularly discussed school work with them performed best in Mathematics (404.60) and Science (410.80). Students whose parents never discussed school work with them performed least in both Mathematics and Science.

Table 10.12: *Performance of Students by Parent Discussion of School Work with the Child*

Frequency of discussions	n	%	Mathematics		Science	
			Mean	SEM	Mean	SEM
Regularly	1,666	39.32	404.60	3.23	410.80	4.25
Sometimes	1,989	51.17	390.45	2.70	392.59	2.93
Not at all	376	9.50	373.32	5.12	365.06	7.24

CHAPTER ELEVEN: PERCEPTION AND ATTITUDES OF PARTICIPANTS

Introduction

Perception is the different ways people consider or view things as they interact with them. The way people view things affects the outcome of any performance since the level of their understanding has a bearing on any activity that they engage in. An attitude is a mind-set that one has towards something; hence their thinking towards that thing will determine how they apply themselves towards given tasks. Perception and attitude contributes towards the confidence that an individual display at any given time, as such showing either a good self-esteem or poor self-esteem. This will usually affect the output due to the rate of delivery and level of delivery being improved or compromised. Table 11.1 below shows that Mathematics teachers were on average motivated with 52.2% being highly motivated and 45.0% being moderately motivated in comparison to only as little as 2.7% not being motivated to teach or to be in the noble profession. This statistics indicates that the confidence level of Mathematics teachers was good and there is need to maintain or improve it in order to have an upward improvement in performance in schools.

Table 11.1: *Confidence of Mathematics Teachers in their Profession*

Level of motivation	Frequency	Percent
Highly motivated	2897	52.2
Moderately motivated	2497	45.0
Lowly motivated	151	2.7

Parents' Perception on Education for Mathematics and Science

The role of parents in students' learning cannot be undermined as they are involved in one way or the other irrespective of their level of education. This creates interest in the students' life towards academics. A child is likely to focus more on their academics and perform better if the parents show the importance of education in one's life and take keen interest in their children's learning. Table 11.2 shows a summary of parents views over the importance of education which was obtained by making an index from the following statements: The school provides good education for my child; I have a good idea of what my child should become; If I won a lot of money I would still keep my child in school; Spending money on education is a good investment.

Parents who had interest or considered education to be of importance for their children were in the majority by 93.59% as compared to 6.41% of those who did not think it was important as shown by Table 11.2. The performance of children whose parents considered education to be important was significantly higher than that of children whose parents don't consider education important for both

Mathematics and Science as displayed in Table 11.2 where in Mathematics, the average mean score was 398.84 compared to 370.22 and in Science the average mean score was 403.12 compared to 361.69. The results show that the perception that parents have towards education concerning their children has an effect on the child's performance.

Table 11.2: *Parents' Perception on Education for Mathematics and Science*

Importance of Education	n	%	Mathematics			Science		
			Mean	SE	SD	Mean	SE	SD
Yes	3 638	93.59	398.84	2.52	80.14	403.12	3.28	103.62
No	243	6.41	370.22	6.34	86.11	361.69	9.34	114.90

Students' Educational Aspirations in Mathematics and Science

To have either a dream or an aspiration as an individual shows you possess one of the hallmarks of people who are successful in life. When one has dreams they work on ways of getting to the desired goal hence visionary people are usually achievers. Most of the successful individuals or institutions usually envisions what they intend to become before they embark on the journey of success, so knowing the extent to which one will go in the education ladder may have an effect on the performance output of an individual. Table 11.3 shows how the performance of students relates to the highest level of Education they wish to achieve. Students who had great ambitions for academic achievement performed much better than those who did not as can be seen in Table 11.3, for both Mathematics (420.08) and Science (433.63). Table 11.3 also shows that the higher the ambition of the student, the greater the performance would be achieved. Those students who had expectations of learning up to tertiary level out performed those who just thought of going up to Upper Secondary School level. At least the majority of the students (76.63%) imagined themselves learning at tertiary.

Table 11.3*: Students' Performance in Relation to their Educational Aspirations in Mathematics and Science*

			Mathematics			Science		
Target Level of achievement	n	%	Mean	SE	SD	Mean	SE	SD
Finish Lower secondary	335	6.15	288.41	4.70	70.63	256.81	5.74	90.87
Finish Upper secondary	511	9.39	327.47	4.50	71.29	298.21	4.41	94.01
Finish Post-secondary, non-tertiary	423	7.83	343.98	5.62	76.47	323.61	7.77	101.96
Finish Short-cycle tertiary	449	8.19	387.58	3.79	69.73	389.58	4.34	89.82
Finish Bachelor's or equivalent	482	8.32	402.92	4.68	73.05	406.82	5.38	91.73
Finish Postgraduate degree	3 595	60.12	420.08	1.94	70.70	433.63	2.62	86.41

Students Sense of School Belonging for Mathematics and Science

A sense of belonging is one of the key factors that can influence the way the students learn and interact with others. People who have a high sense of belonging usually feel at home in a given environment and would be proud to associate with the school both in their social conduct and academic obligations. In this study, students were asked to share their thoughts pertaining to their school, safety, classmates, teachers and learning. The summary of the outcome shown in Table 11.4 indicates that a high sense of school belonging has positive effect on the performance of a student irrespective of the subject. In Table 11.4, those who had a high sense of belonging to their school scored higher average scores of 406.38 for Mathematics and 414.45 for Science while those who had little sense of belonging scored lower average scores of 373.89 for Mathematics and 365.94 for Science. These results show that students with a high sense of belonging had a higher performance than those with little sense of belonging regardless of what subject they do.

Table 11.4: *Performance and Students' Sense of Belonging to Schools for Mathematics and Science*

Subject			Mathematics			Science		
Sense of belonging	n	%	Mean	SE	SD	Mean	SE	SD
High	2 986	52.83	406.38	2.32	71.99	414.45	2.45	91.01
Medium	2 447	42.00	383.12	2.91	87.42	377.98	4.04	115.88
Low	326	5.17	373.89	7.35	97.32	365.94	10.83	135.54

Students like Learning Mathematics and Science

When someone shows keen interest in something, they are likely to appreciate it more and give it more attention than other things.

The behaviour of one who has a liking of a thing always leans towards that particular thing. Whatever an individual likes can be depicted by their behavioural change towards something or attitude towards it. The following statements were used to compile an index for different degrees of liking mathematics and a summary of results in Table 11.5: *I enjoy learning Mathematics; I wish I did not have to study Mathematics; Mathematics is boring; I learn many interesting things in Mathematics; I like Mathematics; I like any schoolwork that involves numbers; I like to solve Mathematics problems; I look forward to Mathematics class; Mathematics is one of my favourite subjects.*

Similar statements were also used for the Science group and a summary of the degree of liking the subject was captured in Table 11.5 as well. The performance of students who indicated that they like learning Mathematics very much was significantly higher (416.10) than those students who did not like learning Mathematics (376.74). Interestingly, those who did not like learning Mathematics scored slightly higher than those who like learning Mathematics which could be a result of some of those who do not like Mathematics being gifted or not finding it difficult to do Mathematics despite their lack of interest.

As for Science, a similar outcome was obtained showing a better performance of those students who said they like learning Science very much. A mean score of (432.01) was observed compared to a mean score of 333.30 for those who did not like learning Science as captured in Table 11.5. Furthermore, the trend of performance showed that the more one liked learning Science the more likely they are to perform well or the better the performance. There were fewer students who did not like Science (6.78%) than those who did not like Mathematics (11.63%).

Table 11.5: *Students' Extent of Liking to Learn Mathematics and Science*

Subject	Extent of like	n	%	Mean	SE	SD
Mathematics	Very Much Like	2 821	50.27	416.10	1.94	70.83
	Like	2 210	38.10	372.56	3.15	84.05
	Do Not Like	736	11.63	376.74	4.97	88.02
Science	Very Much Like	3 237	56.99	432.01	2.49	84.80
	Like	2 108	36.24	352.78	3.67	110.52
	Do Not Like	413	6.78	333.30	9.57	128.44

Students' View on Level of Teacher Engagement During Lessons for Mathematics or Science

The students' perception concerning their teachers in Mathematics and in Science was put into three categories being *Very Engaging teaching, Engaging Teaching* and *Less Engaging Teaching*.

These were a result of a students' evaluations on their interaction with teachers for both Mathematics and Science through the following items or statements: *I know what my teacher expects me to do; My teacher is easy to understand; I am interested in what my teacher says; My teacher gives me interesting things to do; My teacher has clear answers to my questions; My teacher is good at explaining Mathematics / Science; My teacher lets me show what I have learned; My teacher does a variety of things to help us learn; My teacher tells me how to do better when I make a mistake; My teacher listens to what I have to say.*

As indicated by Table 11.6, most students considered the teachers to be very engaging in their teaching, be it Mathematics (59.61%) or Science (56.47%). The performance of the students who perceived that their teachers were very engaging was higher than that of those who perceived that their teachers were less engaging in their teaching approach as evidenced by the higher average mean score of 408.23 compared to a lower average mean score of 378.22 in Mathematics and a higher average mean score of 414.82 compared to a lower average mean score of 382.59 in Science. The student's perception of how the teacher handles the classroom teaching and what opportunities they offer them during learning has the ability to give direction to the performance of an individual student.

Table 11.6*: Students' View on the Level of Engagement in Mathematics Lessons or Science Lessons*

Subject	Level of Engagement	n	%	Mean	SE	SD
Mathematics	Very Engaging	3 388	59.61	408.23	1.81	72.68
	Engaging	1 798	30.70	374.29	3.52	86.49
	Less than Engaging	581	9.69	378.22	6.28	94.55
Science	Very Engaging	3 177	56.47	414.82	2.62	91.08
	Engaging	1 879	32.04	369.76	4.13	117.55
	Less than Engaging	697	11.49	382.59	7.67	124.02

Students' Confidence in Mathematics and in Science

Students were asked to make an evaluation of themselves concerning their confidence in Mathematics or in Science by answering a few questions which considered their perception about Mathematics or Science, how they viewed their performance in comparison to their classmates, whether or not Mathematics or Science was their strength, whether it was easy to grasp concepts or principles of Mathematics or Science and the teacher's view on their aptitude. It was against this background that the index was made to have three levels of confidence mainly *very confident, confident* and *not confident.*

The percentage proportion of students who did not have confidence in either Mathematics or Science was very high with Mathematics being 46.86% and Science being second highest at 42.34% as shown in Table 11.7. The performance of the students who were very confident in Mathematics scored the highest mean (475.43) and those who had no confidence in Mathematics scored the lowest mean (380.67). As for Science, the performance of those who were very confident compared to those who were not confident was similar as in Mathematics with the highest mean score (469.92) being those very confident in Science and the lowest mean (376.49) being for those not confident. In a nutshell, confidence found in a student boasts their ability to perform as that is part of their self-esteem.

Table 11.7: *Students Confidence in Mathematics and in Science*

Subject	Level of confidence	n	%	Mean	SE	SD
Mathematics	Very Confident	514	7.70	475.43	4.59	72.78
	Confident	2 585	45.44	395.98	2.45	78.42
	Not Confidence	2 663	46.86	380.67	2.37	77.08
Science	Very Confident	900	14.47	469.92	4.00	85.70
	Confident	2 456	43.19	392.36	3.14	104.73
	Not Confidence	2 393	42.34	376.49	3.51	103.45

Students' Value on Mathematics or Science

The value that an individual has on something can be at times identified by the attention that is given to that particular thing. Also the value that a person has on something matters, as it determines the extent to which a person is willing to invest in it or obtain it. Students who showed they valued Mathematics or Science depicted a certain trend, as can be seen on Table 11.8 below, of performing quite higher than those who did not value either of the two subjects (Mathematics or Science). In Mathematics, the mean score for those who strongly valued it is 411.38 while those who do not value Mathematics is 311.65, showing a significant difference. Most of the students indicated that they strongly value Mathematics (71.60%) compared to a minority who did not value it at 3.38%.

In Science, the trend was similar as in Mathematics. Students who strongly valued Science performed much better with an average score of 422.52 as compared to a mean score of 291.62 for those who did not value Science. Students who strongly valued Science were in the majority with a proportion of 73.46%.

The trend shown by the results in Table 11.8 indicates that, what an individual values in terms of subjects taught, has a bearing on their performance.

Table 11.8: *Students Value on Mathematics and Science*

Subject	Level of value	n	%	Mean	SE	SD
Mathematics	Strongly Value	4 079	71.60	411.38	1.88	71.74
	Somewhat Value	1 482	25.02	359.22	3.43	87.34
	Do Not Value	193	3.38	311.65	6.85	84.34
Science	Strongly Value	4 150	73.46	422.52	2.31	89.35
	Somewhat Value	1 334	22.66	332.29	4.22	114.82
	Do Not Value	257	3.88	291.62	9.56	120.11

Mathematics and Science Teachers' Job Satisfaction

A relationship between the level of job satisfaction of both the Science teacher and Mathematics teacher against the performance of the students was investigated using the following statements: *I am content with my profession as a teacher; I am satisfied with being a teacher at this school; I find my work full of meaning and purpose; I am enthusiastic about my job; My work inspires me; I am proud of the work I do; I am going to continue teaching for as long as I can.* The results obtained from the responses of the statements was categorised using an index into three being *very satisfied, satisfied* and *less than satisfied*.

Table 11.9 shows that there was no difference in the performance of students, in Mathematics, who were taught by teachers who were *very satisfied* compared to those who were *less than satisfied*. The majority of the Mathematics teachers who were engaged in the study indicated that they were satisfied with their job (86.96%).

As for Science teachers, there was a slight difference in performance for those who were *very satisfied* (401.54) with their job compared to those who were considered to be *less than satisfied (*395.40). There were a greater number of less *than satisfied* teachers in Science (21.58%) than there was in Mathematics (13.04%) though their performance was the same. It seems that even though the teachers are not satisfied, they remained committed to the teaching of students.

Table 11.9: *Mathematics and Science Teachers' Job Satisfaction*

Subject	Job satisfaction	n	%	Mean	SE	SD
Mathematics	Very Satisfied	2 156	35.89	395.09	4.41	85.84
	Somewhat Satisfied	2 737	51.07	387.94	3.18	82.45
	Less than Satisfied	652	13.04	394.00	5.87	78.53
Science	Very Satisfied	1 882	32.19	401.54	6.14	108.79
	Somewhat Satisfied	2 584	46.22	386.83	4.66	107.67
	Less than Satisfied	1 205	21.58	395.40	6.20	108.24

Challenges Facing Mathematics and Science Teachers

Challenges are part of life as they bring out the innovativeness of instructors but when they are overwhelming, it may be discouraging or a hindrance to classroom delivery which will in turn affect the performance at the end.

In Table 11.10, teachers with fewer challenges outperformed those that had many challenges with Science having the highest average score of 415.91 followed by Mathematics average score at 398.22. The table also shows that the teachers were not too overwhelmed with challenges since its natural for some challenges to be handled by individual teachers from time to time. Mathematics had a higher number of fewer challenges than Science as observed in Table 11.10 which was expected as Science is more of a practical subject than Mathematics which requires demonstration in some lessons.

Table 11.10: *Challenges facing Mathematics and Science teachers*

Subject	Extent of challenges	n	%	Mean	SE	SD
Mathematics	Few Challenges	1 164	17.28	398.22	6.02	87.86
	Some Challenges	4 082	76.54	390.16	2.71	81.89
	Many Challenges	299	6.18	385.98	14.07	85.86
Science	Few Challenges	1 117	12.24	415.91	10.51	113.51
	Some Challenges	4 155	79.80	390.32	3.01	107.16
	Many Challenges	439	7.96	394.82	11.02	105.47

Teachers' Confidence in Teaching Mathematics and Science

The confidence that a teacher has in teaching the subject makes interaction in the classroom very lively and interesting as the teacher will not be intimidated by the learners on enquiring on the subject matter or topic in discussion. Confidence of the facilitator in teaching the subject comes with in-depth knowledge of the subject in question hence allowing for learning concepts in depth rather than in a shallow sense. It's difficult to explore different ways of solving and ways of conceptualising ideas when the teacher is not as confident as should be since learners depend entirely upon the teacher to succeed in learning.

Table 11.11 shows that students taught by teachers that are more confident obtained higher average scores for both Mathematics (401.22) and Science (397.70) subjects whereas their counterparts had lower results or scores with Mathematics at 377.78 and Science at 381.17. The output shows that there is a relationship between the level of confidence of a teacher with performance outcomes meaning that the development of a teacher through in-service and workshops will go a long way in creating confident educators.

There was only a handful number of teachers who were not confident in teaching the subject for both Mathematics (4.06%) and Science (7.83%).

Table 11.11: *Teachers Confidence in Teaching Mathematics and Science*

Subject	Confidence level	n	%	Mean	SE	SD
Mathematics	Very confident	1 865	32.46	401.22	5.56	86.89
	Somewhat Confident	3 022	63.48	386.64	3.16	81.67
	Not confident	158	4.06	377.78	8.86	82.77
Science	Very confident	1 557	24.17	397.70	8.13	111.99
	Somewhat Confident	3 740	68.00	394.36	3.92	107.19
	Not confident	350	7.83	381.17	6.20	103.47

CHAPTER TWELVE: DELINEATING FACTORS CLOSELY RELATED TO STUDENTS' ACADEMIC PERFORMANCE

Introduction

Factors affecting performance have been researched by many scholars around the world. Historically, the researchers were looking at education indicators which they use to predict learners performance. The paper by Ogawa, Rodney; Collom (1998) entitled "Educational Indicators: What Are They? How Can Schools and School Districts Use Them?" provided guidance to many policy makers, researchers, practitioners, socialist, economist, etc. on how to identify factors associated with learning. In America, the interest on education indicators dated back to 1867 when statistics about education was collected mainly to help decision making. However, it became evident that due to complexity in the nature of indicators, it was difficult to prescribe effective interventions for widespread and growing social and economic problems of the people (Burstein, Oakes & Guiton, 1992). Despite all this, in the 1980's educational indicators became prominent fixtures on the educational reform landscape. Education indicators are not used to describe the failures of the educational system only but they are also used to hold the education system accountable and also to uncover the causes of educational failures and provide policy makers with solutions.

Ogawa, Rodney; Collom (1998) defined education indicators as statistics that describe the key aspects of schooling which permit the evaluation and monitoring of schools, programs and students. From these activities general assessments (value judgments) of the health of educational systems can be derived and policy-relevant information provided. For Statistics to be an indicator there must be a standard against which it can be judged (Dickson & Lam, 1991). It can be compared to itself over time or across different schools, districts, or other entities. It must act as "vital signs" regarding the "health" of the educational system (Hafner & Buchanan, 1992; Jones & Nielsen, 1994; Kaagan & Coley, 1989; Levesque, Bradby & Rossi, 1996; Oakes, 1986; Nuttall, 1994; Raizen & Jones, 1985). They must permit the monitoring and evaluation of education. They should allow for value judgments to be made about key aspects of the functioning of educational systems (Scheerens, 1991).

Indicators are not arbitrary, isolated measures. They are typically found in sets and comprise what is referred to as an indicator system. They represent relationships between distinct components, providing information on the critical, analytical links (Burstein, Oakes & Guiton, 1992; Jones & Nielsen, 1994; Oakes, 1986; Shavelson et al., 1987; Shavelson, McDonnell & Oakes, 1989). Indicators are developed for each component of the model and the indicator system permits the examination of relationships between various components. These relations are often assumed to be causal (e.g. increased student expenditures lead to increased student achievement.)

Hierarchical Linear Model

The hierarchical linear model is a complex statistical analysis method commonly used to analyze educational data. In the context where data are nested for instance like in educational data, where students are nested within school, it is important for the model to account for the nesting characteristic of the data. There is homogeneity within hierarchal units and that make sense to analysis within and between variability in the units. If nesting of the data is not accounted for, the findings of the analysis can be wrong and jeopardise the significance of the study, for instance in Roberts (2004) study, the results were severely reversed. Raudenbush & Bryk (2002) have noted that disregarding the context of data, i.e. nesting structure of the data may result in aggregation bias, misestimated standard errors and heterogeneity regression.

Proportion of Variation Explained

The proportion of variance explained by each factor is used to determine how much influence a factor has on students' academic performance score. The factors that explain at least 1% of variation in the model according to Nakagawa and Schielzeth (2013), marginal R square measure are considered important.

Fitting HLM to TIMSS Science Data

The preliminary analysis of TIMSS 2015 data sets had shown that there are many factors influencing students' academic performance. There is a need to breakdown these factors into smaller factors which have more association to students' academic performance than others. This will help the policy makers design specific intervention programs which will target few issues but having a lasting effect on student academic achievements. The relationship between the factors must be understood for better formulation and implementation of the relevant intervention. Table 12.1 shows the proportion of factors that are attributable to school, region and students.

Table 12.1: *Proportion of Variance Explained by Random Factors in the HLM Science Model*

	Variability	% of Variability Explained
School	2237	17.29 (2 decimal places)
Region	1039	8.03 (2 decimal places)
Students	9659	74.67 (2 decimal places)
Total	12935	

From Table 12.1 it can be seen that 17.29% of differences in performance is due to schools variability (differences between schools), 8.03% is due to region variability, while 74.67% of differences in performance is due to the nature of students' differences within schools.

Fitting a Saturated HLM model to Science Data

Fifty eight (58) factors from all the questionnaires administered to students, School Heads, Teachers, and parents were fitted to the HLM model. These factors were found to be responsible for 79.78% of the students' differences in performance. The remaining 20.22% differences in students' performances could be accounted for by other factors.

Table 12.2: *Factors Fitted in the HLM Saturated Model*

Factor	Code	Factor	Code
Students Gender	BSBG01	How often eat breakfast on school days	BSBG12
Home Educational Resources	BSDGHER	Frequency of use of Computer	BSBG13A-C
Students Confident in Science	BSDGSCS	Use Internet to do school tasks	BSBG14A-D
Students Value Science	BSDGSVS	Belonging to the School	BSBG15A-G
Student like learning Science	BSDGSLS	Students bullying	BSBG16A-I
Engaging teaching in Science	BSDGESL	Students like learning Science	BSBG21A-I
Home Possessions	BSBG60NEW1	Confidence with Science	BSBG23A-I
Weekly Time Spent on Home	BSDSWKHS	Students Value Science	BSBS24A-I
How many books at Home	BSBG04	Frequency of Homework	BSBS25AB
Sense of School Belonging	BSDGSSB	Extra lessons and tutoring	BSBS26AB
Speaking English at Home	BSBG03	Frequency of Homework	BTBS21A
Digital Devices at Home	BSBG05	Student monitoring and Evaluation	BTBS22A-C
Home possession	BSBG06A-I	Students age	BSDAGE
How far they want to go with Education	BSBG08	Teaching Experience	BTBG01
Guardian Born in Botswana	BSBG09A	School emphasis on academic success	BTDGEAS
Students Born in Botswana	BSBG10A	Safe and orderly School	BTDGSOS
Frequency of Absence from School	BSBG11	School Condition and Resources	BTDGSCR
Challenges facing Teachers	BTDGCFT	Parental Age	BSBH03
Teacher limited by students' Needs	BTDGLSN	Household Source of Income	BSBH10
School Type	SCHOOLTYPE2	Home amenities	BSBH07_IDX
Class Size	BTBG12new	Home belongings	BSBH08_IDX
Difficulty in Understanding English	BTBG13new	Home Chores	BSBH12_IDX
Time spent Teaching Science	BTBG16new	Home chores	recBSBH12_IDX
School Region	REGION2	Place to do homework at school	BCBG08A
School Enrolment	BCBG01new/BCBG02new	Problem affection Teachers	BCBG18A/BCBG18B
Economically disadvantaged	BCBG03A/BCBG04A	Problems among students	BCBG15A-K
Native in English/ population of town	BCBG05A/BCBG05B	Parent relation with students	BSBH01
School provide meal	BCBG06A	Marital Status	BSBH02

There were 58 variables fitted to the HLM model. The objectives were to explore the factors to see which factor explains more variability in students' performance. The amount of variation explained by fixed factors equals the amount explained by both fixed and random factors, suggesting that the factors when controlled for are able to eliminate the difference in mean across schools, i.e. random factor. The fitted factors account for 71.49% of variability in the level 1 units (between students) while the factors account for 100% of variability across level 2 units (schools) according to Raudenbush and Bryk (2002).

Among the fitted factors in the model, 28 belong to students, 12 belong to teachers, 8 belong to the school and 8 to the parents' instruments. Students explained more variability (61.21%), teachers (8.11%), school (6.98%) and parents (3.50%).

Selected Factors Associated with Science Academic Scores

Any factor that was found to account for at least 1% difference in students' performance was considered significant enough. On the basis of this, twenty-five (25) factors out of fifty-eight (58) were found to account for more variability in students' academic performance. As previously noted, 58 factors accounted for 79.78% of students' differences in achievement but only 25 factors were found to be more important than others and they accounted for 61.74% of the differences in performance. Thus the other 33 factors of the 58 accounted for only 9.78% and were thus dropped as insignificant.

Table 12.3: *Variability Accounted for by the Most Important Factors*

Factors	Number of variance	Proportion of variance explained (%)	Variance Explained (%) in level 1	Variance Explained (%) in level 2
Overall Factors	58	79.78	71.49	100
Selected factors	25	70.16	61.74	87.08

Among the 25 factors, it can be deduced that the most important factors to learners' academic performance were intrinsic to learners themselves as seen in Figure 12.1.

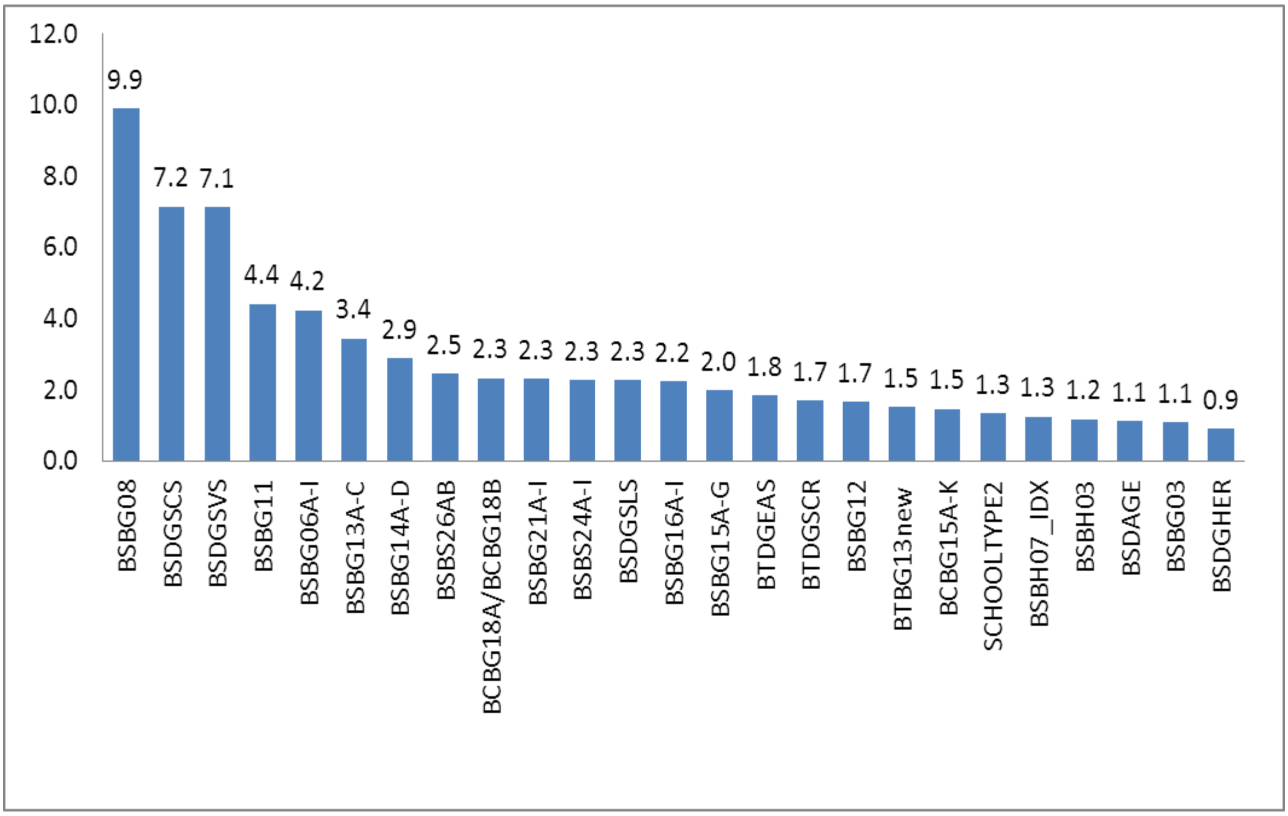


Figure 12.1: *The most Important Factors Accounting for Students' Performance*

The factors that explained the most variation were related to students' perceptions and attitudes. These were BSBG08 (Educational level they expect to complete) at 9.9%, followed by BSDGSCS (perception about learner's confidence in Science) at 7.2% and BSDGSCS (their value of Science) at 7.1%. Previous researches also cited the importance of these factors in students learning (Shavelson, McDonnell & Oakes, 1989).

Another factor explaining high variability was BSBG06A-I (4.2%), which deals with home possession, the availability of home amenities such water, computer, study table, internet connectivity, electricity, running water, TV, etc. thus provides indicators for learner's academic performance.

The frequency of computer use at schools and home (BSBG13A-C), as well as the online use of internet to do the school task (BSBG14A-D) were found to explain more variability of 3.4% and 2.9% respectively. In all, among the 25 factors selected, 15 factors belonged to learners and they explained (60%) variability while the rest belonged to parents, schools, and teachers.

Table 12.4: *Most Important Learner Factors Accounting for Performance*

Factor	Factor code	% explained
Educational level they expect to complete	BSBG08	9.9
Their level of confidence in Science,	BSDGSCS	7.2
The value they attach to Science,	BSDGSVS	7.1
The feel of sense of belonging to the school,	BSBG15	2.0
Perceptions about learning science,	BSBG21	2.3
The level of bullying/ safety at schools	BSBG16	2.2
Frequency of absenteeism from schools	BSBG11	4.4
Availability of home amenities	BSBG06	4.2
Use of computer to do the school related task	BSBG14	6.3
Frequency at which learner eat breakfast at school	BSBG12	1.7
Frequency of English speaking at home	BSBG03	1.1
Availability of home education resources, at home	BSDGHER	0.9

The learner associated factors can be classified into four groups namely: students attitudinal/perceptions factors; socio-economic status of the students; safety and schools; and resources which relates to computer access and internet connectivity.

School and parental factors;

- Teachers' lateness/absenteeism at schools, (BCBG18A/BCBG18B) which accounts for 2.3%
- Safety at school and school discipline (BCBG15A-K) which accounts for 1.5%
- Type of school (government/private) (SCHOOLTYPE2) which accounts for 1.3%
- Age of the parents (BSBH03) which account for (1.3%)
- Home socio-economic status (BSBH07_IDX) which accounts for (1.2%)

The teachers' factors were:

- The tendency for school to emphasize academic success (BTDGEAS) which accounted for (1.8 %)
- The state of the school condition and resources geared towards learning (BTDGSCR) which accounts for (1.7%)
- Number of learners who have difficulty understanding English in the classroom (BTBG13) which accounted for (1.5%)

Factor Differentiability by Types of Schools

The 25 factors obtained in the overall model were fitted in the data for public schools and private schools separately. In government schools, 10.8% of variation in student's scores is accounted for by school differences while 89.2% is accounted for by differences among students. In Private schools, 10% of variation in learners' scores is accounted for by schools while 90% is accounted for by learners' differences.

Selected Factors in public Schools

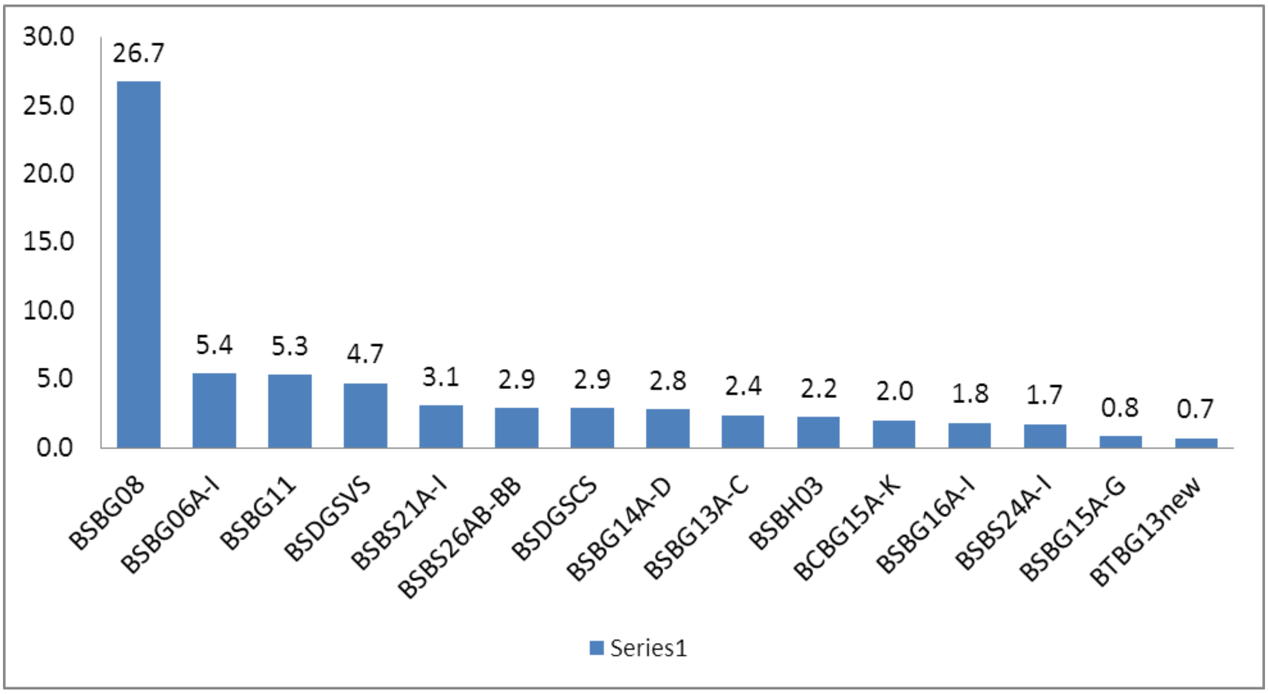


Figure 12.2: *Selected Factors in Public Schools*

The model with 25 factors explained 67.73% of variability in totality. However, the fixed factors accounted for 64.46% of variability in level 1 while 100% of variability is accounted for across schools.

Table 12.5: *Factors Accounted for at least one Percent Variability*

Number of factors	Variance Explained (%)	Variance Explained (%) in level 1	Variance Explained (%) in level 2
25	67.73%	64.46%	100%
15	65.41%	62.46%	94.56%

There were 15 factors which explain at least 1% of variability. The results are shown in Figure 12.3 and Table 12.5. The selected 15 factors account for 65.41% in the model and accounted 62.46% of variability between learners while it accounts for 94.56% across school differences. The student specific factors were found to explain more variability in learners' academic achievement;

- Educational level they expect to complete, BSBG08 (26.7%)
- Availability of home amenities, BSBG06 (5.4%)
- Frequency of absenteeism from schools, BSBG11 (5.3%)
- Perception/attitudes about the value they attach to Science BSDGSVS (5.4%)
- Perceptions about learning Science, BSBG21 (3.1%)
- Extra lessons and tutoring, BSBS26AB (2.9%)
- Perception/attitudes about their level of confidence in Science (BSDGSCS) (2.9%)
- Use of computer to do the school related task, BSBG14 (2.8%)
- The level of bullying/safety at schools, BSBG16 (1.8%)
- The feel of sense of belonging to the school, BSBG15 (2.0%)
- Perception/attitudes about their level of confidence in Science (BSDGSCS) (2.9%)

The school, teachers and parental specific factors found to explain more variability are as follows;

- Number of learners who have difficulty understanding English in the classroom (BTBG13) which accounted for (2.4%)
- School Discipline and Safety (BCBG15) which accounted for (2.0%)
- Age of the parents (BSBH03) which account for 1.3%

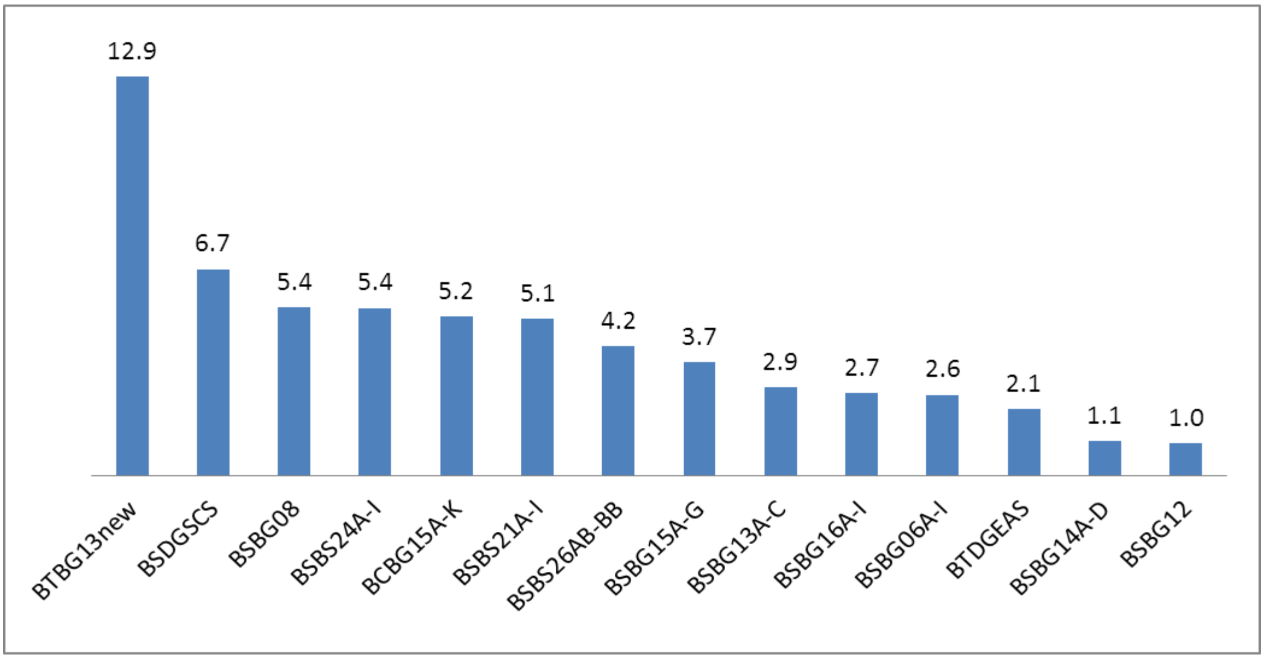


Figure 12.3: *Selected Factors for Private Schools*

Table 12.6: *Variability Accounted for in Private Schools*

Number of factors	Variance Explained (%)	Variance Explained (%) in level 1	Variance Explained (%) in level 2
20	62.92%	56.21%	100%
14	60.97%	55.33%	84.37%

In private school data, 20 factors were fitted and the model accounted for 62.92% of variability. While the fixed factors account for 100% variability between schools, they can only account for 56.21% between students. There were 14 factors which explain at least 1% of variability and account for 60% of variability but accounts for 55.33% of variation in level 1 and 84.37% in level 2. Even though the factors in two school types look similar, the emphasis on their importance differs. The ranking of factors selected for government and private schools differs.

Number of learners who have difficulty understanding English in the classroom (BTBG13) which accounted for (12.9%)

- Their level of confidence in Science, BSDGSCS (6.7%)
- Educational level they expect to complete, BSBG08 (5.4%)
- The value they attach to Science, BSBS24A-I (5.4%)
- Safety at school and school discipline BCBG15A-K which accounts for (5.2%)
- Perceptions about learning Science, BSBG21 (5.1%)
- Extra lessons and tutoring, BSBS26AB (4.2%)
- The feel of sense of belonging to the school, BSBG15 (3.7%)
- The level of bullying/safety at schools, BSBG16 (2.7%)
- Use of computer to do the school related task, BSBG13/ BSBG14 ()
- Availability of home amenities, BSBG06 (2.6%)
- Frequency at which the learner eats breakfast at school, BSBG12 (1.0%)

Factors accounting for performance in each Region

Analysis was conducted for each region to determine important students' factors for their performance. This will assist each region to implement appropriate interventions meant to improve students' performance.

Central Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the Central region are shown below with the proportion of variation it explains.

- Expected Education level (BSBG08) explains 29.4%
- Availability of Home amenities (BSBG06A-I) explains 6.5%
- Value they attach to Science, (BSDGSVS) explains 5.2%
- Frequency of Absent from School, (BSBG11) explains 4.5
- Confidence in Science (BSDGSCS) explains 3.7%
- Their interest in Learning Science (BSBS21A-I) explains 3.2%
- Use of Computer to help school task (BSBG14A) explains 2.5%
- Use of computer at Home (BSBG13A-C) explains 2.4%
- Extra class or Tutoring (BSBS26AB) explains 2.4%
- Student Bullying /School Safety (BSBG16A-I) explains 1.7%
- Frequency of Speak English at Home (BSBG03) explains 0.7%
- Sense of belonging to School (BSBG15A_G) explains 0.6%
- Frequency of breakfast at school (BSBG12) explains 0.6%
- Age of a parent (BSBH03) explains 0.6%
- School safety and Discipline (BCBG15A-I) explains 1.35
- Number of Students with English problems (BTBG13) explains 1.5%

The factors which accounted for more differences in learners' academic performance in the Central region were about learners' expectation about the highest level of education they wish to achieve which accounted for 29.4%. The availability of home amenities such as water, sanitation, shelter and space for reading at home also contributed significantly to learners' academic performance.

Kgatleng Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the Kgatleng region were as follows;

- Availability of Home amenities, (BSBG06A-I) explains 10.60%
- Interest in Learning Science, (BSBS21A-H) explains 12.94%
- The feel of sense of belonging to the school, (BSBG15A-G) explains 8.31%
- Extra lessons and tutoring, (BSBS26AB-BB) explains 6.51%
- Teachers lateness/Absenteeism at school, (BCBG18A-B) 6.46%
- Value they attach for Science, (BSDGSVS) explains 4.90%
- Frequency of Absent from School, (BSBG11) explains 4.66%
- Student Bullying/School Safety, (BSBG16A-I) explains 4.63%
- Use of computer to do school tasks, (BSBG14A-BSBG14D) explains 2.52%
- Use of computer at Home, (BSBG13A-C) explains 2.39%
- State of the school condition and resources, (BTDGSCR) explains 1.08%

Kweneng Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the Kweneng region were as follows;

- Learners Expected Education to Complete, (BSBG08) explains 22.33%
- Safety and School Discipline, (BCBG15A-I) explains 8.21%
- Frequency of Absenteeism from School, (BSBG11) explains 6.54%
- Teachers lateness/Absenteeism at school, (BCBG18A-B) explains 5.93%
- Use of Computer at home, (BSBG13A-) explains 5.02%
- Age of parents, (BSBH03) explains 4.67%
- Value they attach to science learning, (BSBS24A-I) explains 8.24%
- Extra class and tutoring, (BSBS26AB-BB) explains 4.34%
- Use of computer to do school tasks, (BSBG14A-BSBG14D) explains 4.28%
- Level of confidence in Science, (BSDGSCS) explains 4.03%
- Perception about learning Science, (BSBS21A-H) explains 3.27%
- The feel of Sense of belonging, (BSBG15A-G) explains 3.11%
- Home socio economic status, (BSBH07_IDX) explains 2.98%
- Level of bullying/safety at school, (BSBG16A-I) explains 2.51%
- Availability of home amenities, (BSBG06A-I) explains 2.34%
- Number of learners with difficulty understanding English, (BTBG13NEW) explains 1.75%
- Learners age, (BSDAGE) explains 1.40%
- Frequency of breakfast at schools in a week, (BSBG12) explains 0.81%

North East Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the North East region were as follows;

- Expected level of Education to complete, (BSBG08) explains 22.8%
- Teachers lateness/Absenteeism at school, (BCBG18A-B) explains 14.1%
- Frequency of Absenteeism from School, (BSBG11) explains 9.6%
- Age of parents, (BSBH03) explains 7.5%
- Extra class and tutoring, (BSBS26AB-BB) explains 6.3%
- Use of computer to do school tasks, (BSBG14A-BSBG14D) explains 5.9%
- School safety and Discipline, (BCBG15A-I) explains 5.8%
- My interest in Learning Science, (BSBS21A-H) explains 5.7%
- Confidence in Science, (BSDGSCS) explains 3.7%
- Availability of home amenities, (BSBG06A-I) explains 3.0%

- Level of bullying/safety at school, (BSBG16A-I) explains 2.7%
- Value they attach to Science learning, (BSDGSVS) explains 3.6%
- Number of learners with difficulty understanding English, (BTBG13NEW) explains 2.1%
- Sense of belonging to School, (BSBG15A-G) explains 1.8%
- Frequency of English speaking at home, (BSBG03) explains 1.1%
- Home Education Resources, BSDGHER explains 0.7%

North West Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the North West region were as follows;

- Teachers lateness/Absenteeism at school, (BCBG18A-B) explains 28.4%
- Expected level of Education to complete, (BSBG08) explains 15.6%
- Frequency of Absent from School, (BSBG11) explains 10.1%
- Use of Computer to help school task, (BSBG14A-BSBG14D) explains 9.3%
- Number of Students with English problems, (BTBG13NEW) explains 7.2%
- School Emphasis in Academic Success, (BTDGEAS) explains 4.9%
- Use of computer at home, (BSBG13A-C) explains 4.5%
- Value they Attach to Science, (BSBS24A-I) explains 4.1%
- My interest in Learning Science, (BSBS21A-H) explains 4.0%
- Value they attach with Science, (BSDGSVS) explains 3.7%
- Level of bullying/safety at school, (BSBG16A-I) explains 3.6%
- Availability of home amenities, (BSBG06A-I) explains 3.1%
- Level of confidence in Science, (BSDGSCS) explains 1.8%
- Sense of belonging to School, (BSBG15A-G) explains 1.8%
- Frequency of breakfast at school, (BSBG12) explains 0.6%

South East Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the South East region were as follows;

- Teachers lateness/Absenteeism at school, (BCBG18A-B) explains 16.7%
- Expected level of Education to complete, (BSBG08) explains 14.8%
- Availability of home amenities, (BSBG06A-I) explains 9.6%
- Frequency of Absent from School, (BSBG11) explains 7.2%
- Level of confidence in Science, (BSDGSCS) explains 7.1%

- School safety and Discipline, (BCBG15A-I) explains 4.4%
- Number of Student with English problems, (BTBG13NEW) explains 4.2%
- Age of parent, (BSBH03) explains 3.5%
- Interest in Learning Science, (BSBS21A-H) explains 2.7%
- Level of bullying/safety at school, (BSBG16A-I) explains 2.4%
- Extra class or Tutoring, (BSBS26AB-BB) explains 2.4%
- Sense of belonging to School, (BSBG15A-G) explains 1.9%
- School Emphasis in Academic Success, (BTDGEAS) explains 1.7%
- Use of Computer to help school task, (BSBG14A-BSBG14D) explains 1.0%
- Use of computer at home, (BSBG13A-C) explains 0.9%

Southern Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in Southern region were as follows;

- Expected level of Education to complete, (BSBG08)explains 27.64%
- Frequency of Absent from School, (BSBG11) explains 10.93%
- Teachers lateness/Absenteeism at school, (BCBG18A-B) explains 6.86%
- Extra class or Tutoring, (BSBS26AB-BB) explains 6.43%
- Level of confidence in Science, (BSDGSCS) explains 5.97%
- Availability of home amenities, (BSBG06A-I) explains 4.83%
- Value they attach to science learning, (BSBS24A-I) explains 5.25%
- Interest in Learning Science, (BSBS21A-H) explains 3.63%
- Sense of belonging to School, (BSBG15A-G) explains 3.14%
- Use of computer at home, (BSBG13A-C) explains 2.97%
- Level of bullying / safety at school, (BSBG16A-I) explains 2.46%
- School Emphasis in Academic Success, (BTDGEAS) explains 2.44%
- Use of Computer to help school task, (BSBG14A-BSBG14D) explains 2.22%
- Number of Student with English problems, (BTBG13NEW) explains 0.79%

Chobe, Ghanzi and Kgalagadi Regions

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the Chobe, Ghanzi and Kgalagadi region were as follows;

- Expected level of Education to complete, (BSBG08 3) explains 1.90%
- Frequency of Absent from School, (BSBG11) explains 9.48%

- Interest in Learning Science, (BSBS21A-H) explains 9.06%
- Sense of belonging to School, (BSBG15A-G) explains 7.80%
- Level of confidence in Science, (BSDGSCS) explains 7.35%
- Value they attach to Science learning, (BSBS24A I) explains 5.86%
- Level of bullying / safety at school, (BSBG16A-I) explains 4.12%
- Number of learners with difficulty understating English, (BTBG13NEW) explains 4.01%
- Use of computer at home, (BSBG13A-C) explains 3.87%
- Teachers lateness/Absenteeism at school, (BCBG18A-B) explains 3.60%
- Teachers lateness/Absenteeism at school, (BCBG15A-I) explains 3.38%
- Extra class or Tutoring, (BSBS26AB-BB) explains 1.80%
- Use of Computer to help school task, (BSBG14A-BSBG14D) explains 1.28%
- Frequency of breakfast at schools in a week, (BSBG12) explains 1.07%

Factor Commonalities between private and public schools (Science)

The following factors were found to affect both the private and public schools students' performance but to varying degrees.

- Educational level they expect to complete, (BSBG08)
- Availability of home amenities, (BSBG06)
- Perception/attitudes about the value they attach to Science, (BSDGSVS)
- Perceptions about learning Science, (BSBG21)
- Extra lessons and tutoring, (BSBS26AB)
- Use of computer to do the school related task, (BSBG14)
- The level of bullying/safety at schools, (BSBG16)
- The feel of sense of belonging to the school, (BSBG15)
- Perception/attitudes about their level of confidence in Science, (BSDGSCS)
- Number of learners who have difficulty understanding English in the classroom, (BTBG13)
- School Discipline and Safety, (BCBG15)

Factors Common to all Regions (Science)

Likewise, the following factors were found to affect students' performance in all the regions:

- Expected Education level to complete, (BSBG08)
- Frequency of Absenteeism from School, (BSBG11)
- Confidence in Science, (BSDGSCS)
- Interest in Learning Science, (BSBS21A-I)

- Use of Computer to help school task, (BSBG14A)
- Use of computer at Home, (BSBG13A-C)
- Student bullying/school safety, (BSBG16A-I)
- The feel of Sense of belonging to School, (BSBG15A_G)

Fitting a HLM to TIMSS Mathematics Data

Table 12.7: *Proportion of Variance Explained by Random Factors in the HLM Mathematics Model*

	Variability	% of Variability Explained
School	2138	27.75181724
Students	5566	72.24818276
Total Variability	7704	

	Variability	% of Variability Explained
School	1525	19.75900492
Region	626	8.110909562
Students	5567	72.13008551
Total Variability	7718	

The total variability explained by differences between schools in Maths is 27.75% against 72.25% accounted mainly by level 1 unit, i.e. students differences. When a 3 level HLM model is fitted with the school region at level 3, the school variability is partitioned into school variability and regional variability.

The school variability then explains 19.76% while regional differences explain 8.11% of variability in learners' academic achievements.

Table 12.8: *Mathematics Factors and their Description*

Factor Code Factor	Factor Code Factor
BSBG01 (Students Gender)	BSBG12 (How often eat breakfast on school days)
BSDGHER (Home Educational Resources)	BSBG13A-C (Frequency of use of Computer)
BSDGSCM (Students Confident in Science)	BSBG14A-D (Use Internet to do school tasks)
BSDGSVM (Students Value Science)	BSBG15A-G (Belonging to the School)
BSDGSLM (Student like learning Science)	BSBG16A-I (Students bullying)
BSDGESL (Engaging teaching in Science)	BSBG21A-I (Students like learning Science)
BSBG60NEW1 (Home Possessions)	BSBG23A-I (Confidence with Science)
BSDSWKHS (Weekly Time Spent on Home)	BSBS24A-I (Students Value Science)
BSBG04 (How many books at Home)	BSBS25AB (Frequency of Homework)
BSDGSSB (Sense of School Belonging)	BSBS26AB (Extra lessons and tutoring)
BSBG03 (Speaking English at Home)	BTBS21A (Frequency of Homework)

BSBG05 (Digital Devices at Home)	BTBS22A-C (Student monitoring and Evaluation)
BSBG06A-I (Home possession)	BSDAGE (Students age)
BSBG08 (How far they want to go with Education)	BTBG01 (Teaching Experience)
BSBG09A(Guardian Born in Botswana)	BTDGEAS (School emphasis on academic success)
BSBG10A (Students Born in Botswana)	BTDGSOS (Safe and orderly School)
BSBG11 (Frequency of Absent from School)	BTDGSCR (School Condition and Resources)
BTDGCFT (Challenges facing Teachers)	BSBH03 (parental Age)
BTDGLSN (Teacher limited by students' Needs)	BSBH10 (Household Source of Income)
BCBG06A (School provide meal)	BSBH07_IDX (Home amenities)
SCHOOLTYPE2 (School Type)	BSBH08_IDX (Home belongings)
BTBG12new (Class Size)	BSBH12_IDX (Home Chores)
BTBG13new (Difficulty in Understanding English)	recBSBH12_IDX (Home chores)
BTBG16new (Time spent Teaching Science)	BCBG15A-K (Problems among students)
REGION2 (School Region)	BSBH01 (Parent relation with students)
BCBG01new/BCBG02new (School Enrolment)	BSBH02 (Martial Status)
BCBG03A/BCBG04A (Economically disadvantaged)	BCBG08A (Place to do homework at school)
BCBG05A/BCBG05B (Native in English)/ population of town)	BCBG18A/BCBG18B (Problem affection teachers)

The HLM fitted to 64 factors explained 82.30% variability in the learners' performance scores according to marginal and conditional R square measure (Nakagawa and Schielzeth, 2013). The fitted factors explained 74.84% of variability in level 1 according to Raudenbush and Bryk (2002, pp. 74 and 79) (i.e. differences between learners). However, the fitted factors accounted for 100% variability in level 2 (differences between schools).

Selected Factors

Among the 64 factors investigated, 32 factors were found to explain at least 1% of the differences in learners' academic performance.

Table 12.9: *Selected Factors Explaining more Variability in Mathematics Performance*

	Number of factors	Variance Explained (%)	Variance Explained (%) in level 1	Variance Explained (%) in level 2
Overall factors	64	82.30%	74.84%	100%
Selected factors	32	76.57%	70.53%	92.51%

In totality, these selected factors explained 76.57% of variability, while they explain 70.53% within level 1 units and 92.51% in level 2 units. The other 32 factors not selected by the model in totality accounted for only 5.73%.

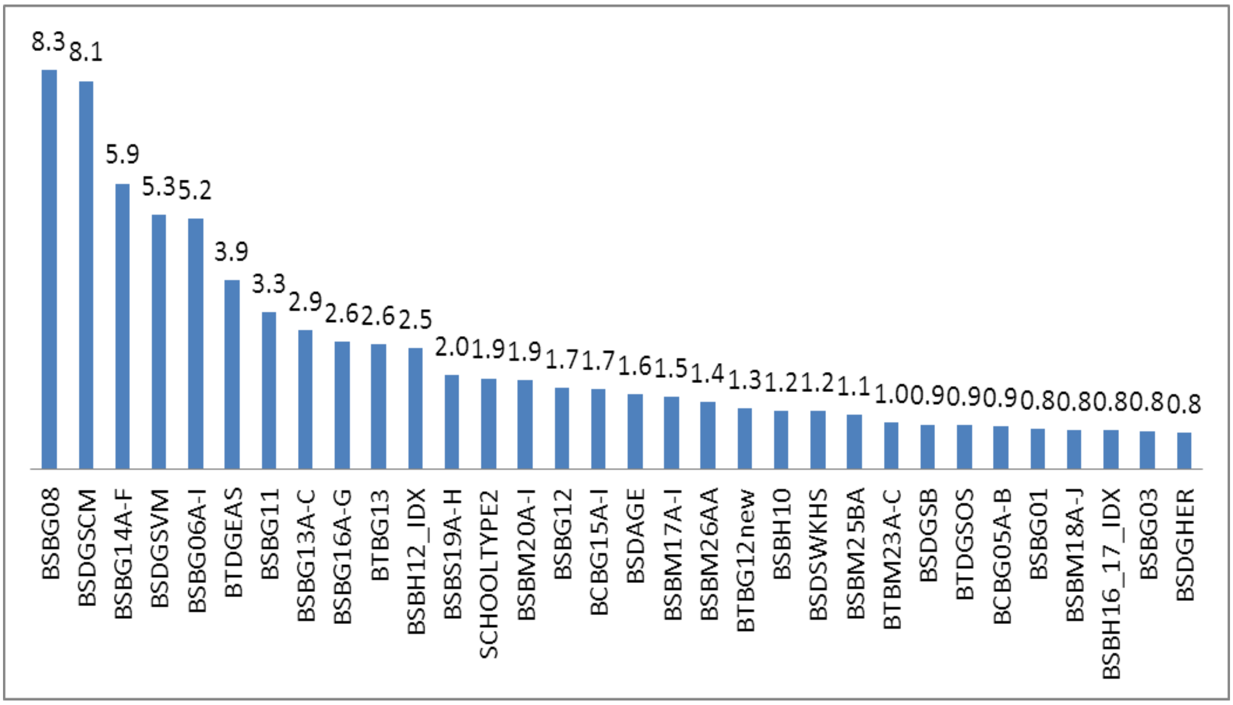


Figure 12.4*: Maths Selected Factors*

The learners' specific factors which accounted for more variability in learners' academic performance are as follows;

- How far in their education do they expect to go, (BSBG08) explains 8.27%
- Their level of confidence in Mathematics, (BSDGSCS) explains 8.05%
- Accessibility to computer (BSBG13) and the ability to use computer, (BSBG14) explains 8.8%
- The value they attach to Maths, (BSDGSVM/ BSBM20A-I) explains 7.12%
- Availability of home amenities, (BSBG06) explains 5.2%
- Frequency of absenteeism from schools, (BSBG11) explains 3.26%
- The level of bullying/ safety at schools, (BSBG16) explains 6.21%
- The frequency at which learner eat breakfast at school, (BSBG12) explains 1.68%
- The learners age, (BSDAGE), (1.6%) explains 1.56%
- Perceptions about learning Mathematics, (BSBG17) explains 1.5%
- Weekly times spend in Mathematics homework, (BSDSWKHS/BSBM25BA) explains 2.33%
- Student Gender, (BSBG01) explains 0.83%
- Engaging teaching, (BSBM18A-J) explains 0.82%
- The frequency at which learners speak English at home, (BSBG03) explains 0.8%
- Availability of education resources, (BSDGHER) explains 0.76%

The teachers, school and parental specific factors which accounted for more variability in learners' Mathematics academic performance are as follows;

- The tendency for school to emphasis on academic success, (BTDGEAS) explains 3.92%
- Number of learners who have difficulty understanding English, (BTBG13) explains 2.59%
- Number of students in the classroom, (BTBG12new) explains 1.27%
- Methods of monitoring students' performance, (BTBM23A-C) explains 0.98%
- Safe and orderly schools, (BTDGSOS) explains 0.92%
- Safety at school and school discipline, (BCBG15A-K) explains 1.67%
- Type of school (government/private), (SCHOOLTYPE2) explains 1.89%
- Socio-economic status of the area the school is located, (BCBG05A-B) explains 0.90%
- Home socio-economic status, (BSBH07_IDX) explains 2.51%
- Source of income of the household, (BSBH10) explains 1.22%
- Fathers and Mothers highest education level, (BSBH16_17_IDX) explains 0.81%

Factor Differentiability by Types of School (Private versus Public Schools)

Table 12.10: *Factor Differentiability by Type of School*

Number of factors	Variance Explained (%)	Variance Explained (%) in level 1	Variance Explained (%) in level 2
32	72.46%	70.00%	100%
20	68.48%	65.78%	87.42%

The 32 factors selected were fitted to public schools and accounted for 72.46% differences in learners' academic performances in total but explained 70.0% of variability in level 1 and 100% in level 2. From these factors only 20 factors were found to explain at least 1% and in total explained 68.48%

Public Schools

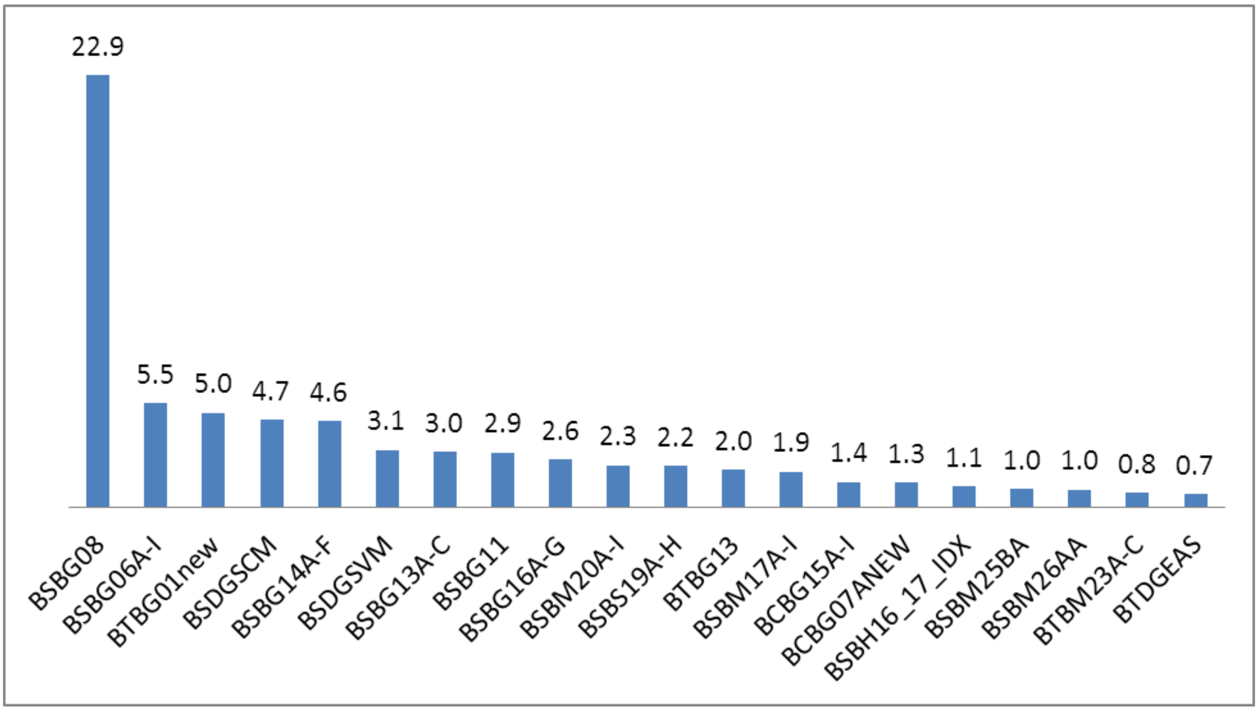


Figure 12.5*: Maths Public School Factors*

The learners, teachers, school and parental specific factors which accounted for more variability in learners' Mathematics academic performance in public schools are as follows;

- Expected Education level to complete, (BSBG08) explains 22.86%
- Availability of Home amenities, (BSBG06A-I) explains 5.54%
- Student Gender, (BTBG01new) explains 5.03%
- Their level of confidence in Mathematics, (BSDGSCM) explains 6.88%
- The ability to use computer, (BSBG14A-F) explains 4.58%
- The value they attach to Mathematics, (BSDGSVM/BSBM20A-I) explains 3.06%
- Accessibility to computer at home/school, (BSBG13) explains 2.99%
- Frequency of absenteeism from schools, (BSBG11) explains 2.94%
- The level of bullying/ safety at schools, (BSBG16A-G) explains 2.57%
- The Number of learners who have difficulty understanding English, (BTBG13) explains 2.01%
- Perceptions about learning mathematics, (BSBM17A-I) explains 1.91%
- Safety at school and school discipline, (BCBG15A-I) explains 1.38%
- Days per year school open, (BCBG07ANEW) explains 1.35%
- Home socio-economic status, (BSBH16_17_IDX) explains 1.14%

- Weekly times spent in Mathematics homework, (BSBM25BA) explains 1.01%
- Extra Lessons and Tutoring, (BSBM26AA) explains 0.97%
- Methods of monitoring students' performance, (BTBM23A-C) explains 0.79%
- The tendency for school to emphasis on academic success, (BTDGEAS) explains 0.71%

Table 12.11: *Selected Factors for Private Schools*

Factor	Number of factors	Variance Explained (%)	Variance Explained (%) in level 1	Variance Explained (%) in level 2
Overall factors	32	82.98%	76.10%	100%
Selected factors	16	80.26%	66.94%	100%

In private schools, 16 factors were from the 32 factors and these accounted for 80.26%, and the omitted 16 factors only accounted for 2.72%. The selected factors accounted for 66.94% in level 1 units and 100% in level 2 units.

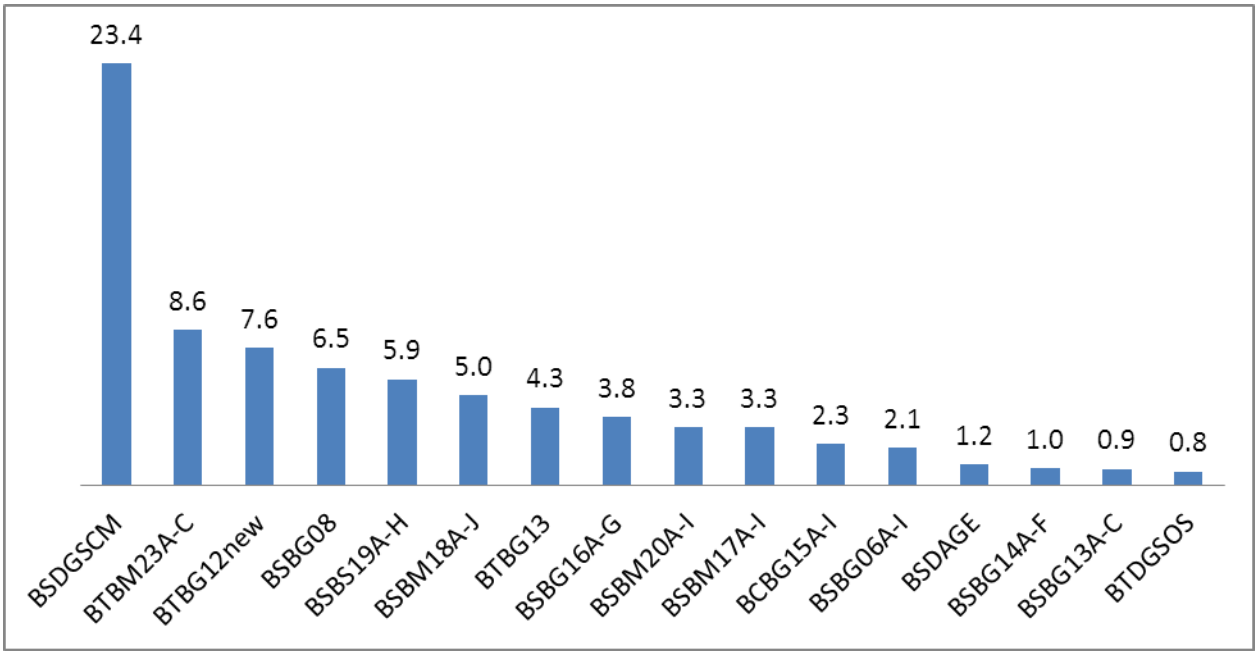


Figure 12.6: *Mathematics Private School factors*

The learners, teachers, school and parental specific factors which accounted for more variability in learners' Mathematics academic performance in private schools are as follows;

- Their level of confidence in Mathematics, (BSDGSCM) explains 29.4%
- Methods of monitoring students' performance, (BTBM23A-C) explains 8.6%
- The number of students in the classroom, (BTBG12 new) explains 7.6%
- How far in their education do they expect to go, (BSBG08) explains 6.5%

- Engaging learning and teaching, (BSBM18A-J) explains 5.0%
- The Number of learners having difficulty understanding English, (BTBG13) explains 4.3%
- The level of bullying/safety at schools, (BSBG16A-G) explains 3.8%
- The value they attach to Mathematics, (BSBM20A-I) explains 3.3%
- Perceptions about learning Mathematics, (BSBM17A-I) explains 3.3%
- Safety at school and school discipline, (BCBG15A-I) explains 2.3%
- Availability of Home amenities, (BSBG06A-I) explains 2.1%
- Students' age, (BSDAGE) explains 1.2%
- The ability to use computer, (BSBG14A-F) explains 1.0%
- Accessibility to computer at home/school, (BSBG13A-C) explains 0.9%
- Safe and orderly schools, (BTDGSOS) explains 0.8%

Factors accounting for performance in each Region

Analysis was conducted for each region to determine important students' factors for their performance. This will assist each region to implement appropriate interventions meant to improve students' performance.

Central Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in Central region were follows;

- Expected Education level to complete, (BSBG08) explains 25.3%
- Their level of confidence in Mathematics, (BSDGSCM) explains 13.1%
- Availability of Home amenities, (BSBG06A-I) explains 4.8%
- Home Chores after School, (BSBH12_IDX) explains 4.1%
- Accessibility to computer at home/school, (BSBG13A-C) explains 4.0%
- The ability to use computer, (BSBG14A-F) explains 3.9%
- Safety at school and school discipline, (BCBG15A-I) explains 3.7%
- Frequency of absenteeism from schools, (BSBG11)explains 2.9%
- The level of bullying/ safety at schools, (BSBG16A-I) explains 2.6%
- Perceptions about learning mathematics, (BSBM17A-I) explains 2.4%
- Source of income of the household, (BSBH10) explains 2.3%
- Days per year school open, (BCBG07Bnew) explains 1.7%
- The value they attach to Mathematics, (BSBM20A-I) explains 1.7%

- The Number of learners having difficulty understanding English, (BTBG13) explains 1.7%
- Fathers and Mothers highest education level, (BSBH16_17_IDX) explains 1.6%
- Home socio-economic status, (BCBG07Anew) explains 1.5%
- The tendency for school to emphasis on academic success, (BTDGEAS) explains 1.2%
- Socio-economic status of the area the school is located, (BCBG05A-B) explains 1.2%
- Engaging teaching, (BSBM18A-J) explains 0.9%
- Availability of education resources, (BSDGHER) explains 0.9%
- The frequency at which learner eat breakfast at school, (BSBG12) explains 0.8%
- The number of students in the classroom, (BTBG12new) explains 0.8%

Chobe, Ghanzi and Kgalagadi

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in Chobe, Ghanzi and Kgalagadi region were as follows;

- Expected Education level to complete, (BSBG08) explains 31.5%
- The value they attach to Mathematics, (BSBM20A-I) explains 12.3%
- Their level of confidence in Mathematics, (BSBM19A-H) explains 11.4%
- The level of bullying/ safety at schools, (BSBG16A-I) explains 6.5%
- Perceptions about learning Mathematics, (BSBM17A-I) explains 4.9%
- Accessibility to computer at home/school, (BSBG13A-C) explains 4.1%
- The ability to use computer, (BSBG14A-F) explains 3.7%
- Frequency of absenteeism from schools, (BSBG11) explains 3.7%
- Availability of home amenities, (BSBG06A-I) explains 2.9%
- Extra Lessons and tutoring, (BSBM26AA-AB) explains 2.2%
- Weekly times spent in Mathematics homework, (BSBM25BA) explains 0.9%
- Student age, (BSDAGE) explains 0.7%

Kgatleng Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in Kgatleng region were as follows;

- Expected Education level to complete, (BSBG08) explains 18.82%
- The ability to use computer, (BSBG14A-F) explains 8.72%
- Availability of home education resources, (BSDGHER) explains 8.04%

- The value they attach to Mathematics, (BSBM20A-I) explains 13.49%
- Availability of home amenities, (BSBG06A-I) explains 6.76%
- Engaging teaching, (BSBM18A-J) explains 6.53%
- Perceptions about learning Mathematics, (BSBM17A-I) explains 6.34%
- The level of bullying/safety at schools, (BSBG16A-I) explains 6.34%
- Their level of confidence in Mathematics, (BSBM19A-H) explains 6.11%
- The frequency at which learner eat breakfast at school, (BSBG12) explains 4.32%
- Frequency of absenteeism from schools, (BSBG11) explains 2.96%
- Accessibility to computer at home/school, (BSBG13A-C) explains 2.82%
- Student Age, (BSDAGE) explains 1.30%
- The tendency for school to emphasis on academic success, (BTDGEAS) explains 1.06%
- Weekly times spend in mathematics homework, (BSBM25BA) explains 1.64%

Kweneng Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in Kweneng region were as follows;

- Expected Education level to complete, (BSBG08) explains 18.30%
- The ability to use computer, (BSBG14A-F) explains 13.43%
- The Number of learners having difficulty understanding English, (BTBG13) explains 12.45%
- Methods of monitoring students' performance (BTBM23A-C) explains 9.32%
- Perceptions about learning Mathematics, (BSBM17A-I) explains 5.26%
- The level of bullying/safety at schools, (BSBG16A-I) explains 5.15%
- Availability of Home amenities, (BSBG06A-I) explains 4.98%
- Their level of confidence in Mathematics, (BSBM19A-H) explains 4.24%
- The value they attach to Mathematics, (BSBM20A-I) explains 6.57%
- Frequency of absenteeism from schools, (BSBG11) explains 3.74%
- Engaging teaching, (BSBM18A-J) explains 2.22%
- Accessibility to computer at home/school, (BSBG13A-C) explains 2.00%
- Extra Lessons and Tutoring, (BSBM26AA) explains 1.13%
- Weekly times spend in Mathematics homework, (BSBM25BA) explains 0.97%

North East Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in North East region were as follows;

- Expected Education level to complete, (BSBG08) explains 19.05%
- The value they attach to Mathematics, (BSDGSVM) explains 22.87%
- The level of bullying/ safety at schools, (BSBG16A-I) explains 6.33%
- Number of learners who have difficulty understanding English, (BTBG13) explains 5.22%
- Frequency of absenteeism from schools, (BSBG11) explains 5.05%
- Methods of monitoring students' performance, (BTBM23A-C) explains 4.63%
- Engaging learning and teaching, (BSBM18A-J) explains 4.60%
- Availability of education resources, (BSDGHER) explains 4.30%
- Days per year school open, (BCBG07A new) explains 3.82%
- Their level of confidence in Mathematics, (BSBM19A-H) explains 3.72%
- Availability of Home amenities, (BSBG06A-I) explains 3.71%
- Weekly times spend in Mathematics homework, (BSBM25BA) explains 4.71%
- The frequency at which learner eat breakfast at school, (BSBG12) explains 3.25%
- Safety at school and school discipline, (BCBG15A-I) explains 3.19%
- Perceptions about learning mathematics, (BSBM17A-I) explains 3.15%
- Home socio-economic status, (BCBG07B new) explains 1.97%
- Student Age, (BSDAGE) explains 1.24%
- The tendency for school to emphasise academic success, (BTDGEAS) explains 1.15%

North West Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the North West region were as follows;

- The Number of learners who have difficulty understanding English, (BTBG13) explains 13.18%
- Expected Education level to complete, (BSBG08) explains 12.69%
- The ability to use computer, (BSBG14A- F explains 9.68%
- The tendency for school to emphasis on academic success, (BTDGEAS) explains 7.86%
- Perceptions about learning Mathematics, (BSBM17A-I) explains 7.26%
- Their level of confidence in Mathematics, (BSBM19A-H) explains 6.95%
- Availability of Home amenities, (BSBG06A-I) explains 6.18%
- The value they attach to Mathematics, (BSBM20A-I) explains 6.38%
- Engaging teaching, (BSBM18A-J) explains 5.05%
- The level of bullying/safety at schools, (BSBG16A-I) explains 4.62%
- Weekly times spend in Mathematics homework, (BSBM25BA) explains 4.71%

- Methods of monitoring students' performance, (BTBM23A-C) explains 3.01%
- Availability of education resources, (BSDGHER) explains 2.89%
- Accessibility to computer at home/school, (BSBG13A-C) explains 2.21%
- Frequency of absenteeism from schools, (BSBG11) explains 1.97%
- Student Age, (BSDAGE) explains 1.69%
- Extra Lessons and Tutoring, (BSBM26AA) explains 0.94%
- Weekly times spend in Mathematics homework, (BSDSWKHS) explains 0.81%

South East Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the South East region were as follows;

- The ability to use computer, (BSBG14A-F) explains 12.97%
- The Number of learners having difficulty understanding English, (BTBG13) explains 9.87%
- Expected Education level to complete, (BSBG08) explains 9.66%
- Availability of Home amenities, (BSBG06A-I) explains 8.45%
- Safety at school and school discipline, (BCBG15A-I) explains 7.45%
- The level of bullying/ safety at schools, (BSBG16A-I) explains 6.42%
- Perceptions about learning Mathematics, (BSBM17A-I) explains 4.98%
- The tendency for school to emphasis on academic success, (BTDGEAS) explains 4.92%
- Their level of confidence in Mathematics, (BSBM19A-H) explains 4.03%
- Student Age, (BSDAGE) explains 3.17%
- Engaging teaching, (BSBM18A-J) explains 2.21%
- The value they attach to Mathematics, (BSBM20A-I) explains 2.18%
- Weekly times spent in Mathematics homework, (BSBM25BA) explains 2.08%
- Methods of monitoring students' performance, (BTBM23A-C) explains 2.05%
- Extra Lessons and Tutoring, (BSBM26AA) explains 1.82%
- Availability of education resources, (BSDGHER) explains 1.50%
- The frequency at which learner eats breakfast at school, (BSBG12) explains 1.44%
- Frequency of absenteeism from schools, (BSBG11) explains 1.28%
- Home socio-economic status, (BCBG07A new) explains 1.02%
- Accessibility to computer at home/school, (BSBG13A-C) explains 0.79%

Southern Region

The learners, teachers, schools and parents factors found to account for more differences in learners' academic performance in Science in the Kgatleng region were as follows;

- Expected Education level to complete, (BSBG08) explains 22.80%
- The ability to use computer, (BSBG14A-F) explains 11.66%
- Availability of Home amenities, (BSBG06A-I) explains 7.37%
- Methods of monitoring students' performance, (BTBM23A-C) explains 7.06%
- Their level of confidence in Mathematics, (BSBM19A-H) explains 6.27%
- The level of bullying/safety at schools, (BSBG16A-I) explains 7.55%
- The value they attach to Mathematics, (BSBM20A-I) explains 7.13%
- Engaging teaching, (BSBM18A-J) explains 3.93%
- Perceptions about learning Mathematics,(BSBM17A-I) explains 3.74%
- Frequency of absenteeism from schools, (BSBG11) explains 3.58%
- Accessibility to computer at home/school, (BSBG13A-C) explains 2.44%
- Socio-economic status of the area the school is located, (BCBG05A-B) explains 2.40%
- Student Age, (BSDAGE) explains 2.15%
- The tendency for school to emphasis on academic success, (BTDGEAS) explains 1.46%
- Extra Lessons and Tutoring, (BSBM26AA) explains 2.30%
- Safety at school and school discipline, (BCBG15A-I) explains 1.09%
- The number of students in the classroom, (BTBG12 new) explains 1.03%
- Weekly times spend in Mathematics homework, BSBM25BA explains 0.89%
- The frequency at which learner eats breakfast at school, (BSBG12) explains 0.75%

CHAPTER THIRTEEN: CONCLUSION

Botswana administered TIMSS to ninth grade (Form 2) students while internationally the test was administered to eighth grade students. This was the second time since Botswana started participating in this international study in 2003. Botswana students at eighth grade were found to be seriously challenged by the test items, hence the recommendation by the TIMSS office to switch to ninth grade. TIMSS instruments compromised of tests and questionnaire instruments for students, parents, teachers, and School Heads. The test consisted of Mathematics items and Science items in the same booklet.

There were 14 booklets in all containing different items. Each item was contained in 2 different booklets. Students were writing different booklets of the 14, depending on the sampling. The main administration was preceded by a field test. In each case, administration was coordinated by teachers identified from the participating school. In all, two classes from 18 schools administered the field test while one class from 160 schools administered the main survey, with some exceptions in schools with small class sizes.

Scoring was done by teachers after rigorous training by the National TIMSS team after undergoing training conducted by the TIMSS office. For a country to be allowed to participate in TIMSS, its National Curriculum should match at least 75% of the International Assessment Frameworks. The match between Botswana curricula and the international frameworks was found by experts to be 94% and 88% for Mathematics and Science respectively. Botswana identified 207 items/score points out of 221 and 197 items/score points out of 233 for Mathematics and Science respectively, to be directly coming from its curricula.

Botswana students scored 390 in Mathematics and 391 in Science, far much below the scale centre point of 500 in both Mathematics and Science, attaining fifth and third positions from the bottom out of thirty nine countries. This performance represents 23% and 29% pass in Mathematics and Science respectively, compared to 42% pass in Mathematics and 44% pass in Science internationally. However about the same performance was recorded (23% for Mathematics and 28% for science) on items identified to be coming from its curricula. Botswana students were thus not only unable to achieve high scores in the total TIMSS items but also in the test coming from their own curricula, an indication that Botswana curriculum was at par with international standards. This point to the fact that there are some other circumferential factors, apart from the curricula, that hindered high achievement in their own curricula. Botswana scored about the same on other countries curriculum, a further indication that our curriculum was at par with international standards.

As a consequence, no country was favoured by the TIMSS assessment frameworks.

Since participating in the study in 2003, Botswana's performance has been declining in each successive cycle, even after switching to the ninth grade (while others use eighth grade), despite improvement internationally. Botswana girls continue to perform far much better than boys, a rare phenomenon also experienced by other countries. It is worth noting that Botswana is the second country with the highest significant differences between girls' and boys' performance in Mathematics.

Although students in private schools constitute only 2.2% of the students population, hence inferential analysis could not be performed, their performance was far much higher than that of students in public schools in both Mathematics (521.97) and Science (540.32). They performed above the TIMSS scale centre point of 500, outperforming public schools by at least 100 points, and only 57 points and 99 points below the top performing countries in Science and Mathematics respectively.

Of the ten regions, the South East performed the highest in both subjects, followed by the North East, and the only ones with a mean performance above 400, while the Kgalagadi region performed the least in both subjects. Four regions, namely South East, North East, Kgatleng and Chobe, scored above the country mean in both Mathematics and Science. On the other hand, Kgalagadi, Southern and Kweneng regions scored far below the country mean, hence contributed significantly in the country's low mean score. The latter would need more assistance either in terms of resource allocation or system support. It must be noted that statistical comparison could not be made due to variances in population sizes.

Some items were so difficult for the students to an extent that they either, did not attempt to answer them, even some multiple choice items which involve guessing, or the percent correct was so low. The percent correct for Mathematics items ranged from 6% to 78% with an average percent correct of 33% compared to the international average percent correct of 15% to at least 78%. On the other hand, the percent correct for Science items ranged from 6% to 78% with an average percent correct of 35% compared to international average percent correct of 20% to at least 78%. As already seen that the TIMSS test was difficult for Botswana students, thirty-seven (37) multiple choice items out of 115 were accessible to Botswana students compared to 85 internationally in Mathematics while in Science, 78 multiple choice items out of 145 were accessible to Botswana students compared to 124 international average. Up to 15% of the students omitted Mathematics multiple choice items and up to 24% of structured items, while in Science, it was up to 35% of multiple choice items and up to 25% of structured items.

The omitted items or items with low percent correct that proved to be problematic for Botswana students were identified to be from Geometry and Data and Chance content domains in Mathematics, while in science, it was Earth Science, and Physics. This could be an indication that either teachers were not well prepared from Colleges in these topic areas or the topics were naturally difficult for the students. However, although other content domains were not that much of a problem, there were certain topic areas within them that were giving students problems. In particular, students found items difficult from knowledge cognitive domain in Science and application cognitive domain in Mathematics.

Specific topic areas for Mathematics that were problematic to students were:

- *Number*: Fractions, decimals and integers; Ratio, proportion and percent; Whole numbers
- *Algebra*: Equations and inequalities; Expressions and operations; Relationships and functions
- *Geometry*: Geometric measurement; Geometric shapes; Location and movement,
- *Data & Chance:* Chance, Characteristics of data sets; and Data interpretation

Specific topic areas for Science that were problematic to students were:

- *Biology*: Composition of matter; Cells and Their Functions; Characteristics and Life Processes of Organisms; Diversity, Adaptation, and Natural Selection; Ecosystems; Life Cycles, Reproduction, and Heredity; Human Health;
- *Physics*: Light and sound; and Electricity and magnetism; Energy Transformation and Transfer; Forces and Motion; Physical States and Changes in Matter;
- *Earth Science:* Earth processes, cycles and history; and Earth structures and physical features; Earth in the solar system and the universe; Earth's resources, their uses and conservation;
- *Chemistry:* Properties of Matter; Chemical Change; Properties of Matter; Physical states and changes in matter; Physical states and changes in matter;

Contextual factors were found to be associated with performance. Of the 58 factors which were linked to learners' academic performance, 25 of them were identified as more prominent. The identified factors explain more differences in the learners' academic performance compared to others.

The 58 factors explain 80% of the differences in the learners' performance while the selected factors were found to account for 70.15% differences. The selected factors were the following:

- 17 Students specific factors (57.5%)
- 3 Teachers specific factors (5.1%)

- 3 School specific factors (5.1%)
- 2 parental specific factors (2.4%)

The learners' specific factors that were found important for academic performance were mainly concerned with learners' attitude and perception towards learning in general, bullying by other learners at schools, availability of home amenities (socio-economic status of their home), availability of computer aided learning at schools;

- How far in their education do they expect to go which accounted for more difference compared to all selected factors (9.9%)?
- Perception/attitudes about their level of confidence in Science which account for (7.2%). Perception/attitudes about the value they attach to Science which account (7.2%).
- Perceptions about sense of belonging to the school which contribute 2.0 %)
- Perceptions about learning Science which account for 2.3%
- The level of bullying/safety at schools which contribute 2.2%)
- Frequency of absenteeism from schools which accounts for (4.4%)
- Availability of home amenities which accounted for 4.2%
- The accessibility to computer and the ability to use computer to do the school related task which all account for (6.3%)
- The frequency at which learner eats breakfast at school was found to explain 1.7%
- The frequency at which learners speak English at home was found to explain 1.1%
- The availability of education resources at home which accounted for 0.9%

The teachers' specific factors which were found to account for more differences in learners' academic achievements were mainly concerned with:

- The tendency for school to emphasis on academic success which accounted for 1.8 %
- The state of the school condition and resources geared towards learning which accounts for 1.7%
- The proportion of learners who have difficulty understanding English in the classroom which accounted for 1.5%.

CHAPTER FOURTEEN: RECOMMENDATIONS

Recommendations

The study identified a number of issues which can be addressed by the following recommendations:

1. The institution for teacher training should give more attention when training teachers to Data and Chance and Geometry in Mathematics and Earth Science, Chemistry and Physics in Science. For in-service teachers, more workshops should be conducted to impart teachers with the necessary knowledge and skills in these topics.

2. Given that schools are less safe and orderly than before, and that indiscipline and bullying are at a rise, it is imperative therefore that schools should hire people trained to be able to identify students who are bullied and yet fear to come out so that they can be helped before it causes irreparable damage to them, as well as identify those bullying others so that remedial action could be taken whilst it's in its infancy.

3. The school system should thus put in place the support system to curb bullying through/by hiring professionals such as Social Workers, Counsellors and/or a Psychologist who would be able to identify signs of bullying or being bullied either on the perpetrators or victims. They will teach students skills for handling bullies through role-playing and other technics to identify bullies. They will also help the bullied, the bullies and those who help the bullies. When necessary, these children should be referred to outside therapists for help with activities that create awareness about bullying. The professionals should discuss the matter with the parents of the perpetrator and the victim.

4. The schools should establish a school culture of cooperation and collaboration between the various stakeholders for effective teaching and learning. There should be a strong linkage between the school and the community at large and the community should influence what the school is teaching and what students are learning. Likewise, there should be a strong thread within the micro society of the school, where the different players know and understand what each one is doing. Thus, management should be a strong component of any institution that desires to succeed in its endeavor. Management should be able to steer the players to work together as a team.

5. The use of digital devices in learning should be highly encouraged as they have a positive relationship with students' performance in Mathematics and Science.

Thus, the ministry should ensure that all schools are equipped with digital devices to facilitate learning and provide a diverse source of information from the teacher. However, the use of digital devices should be monitored and controlled so that they do not end up being used for other purposes not related to learning.

6. The ministry should come up with means to encourage participation of parents, the community and society at large, in children's education. When parents are well informed of their contribution to their children's school work, they will be able to assist with homework, avoid over engagement of the child on home chores, and participate in the school's decision making process. Parents should take keen interest in their children's education through different forums that are provided for in school structures so that they can contribute to the improvement of their children's performance. It is also important for the parents to show their children how much they value education by talking to their children about it, attending PTA meetings and engage in programs which are arranged by schools for Parents – Teacher-Students interaction to evaluate performance.

7. Schools should devise means of allowing students to be involved in decision making so that they change the school's outlook and how things are done at the school which will ultimately increase their sense of belonging to the schools. Students should be allowed to choose the subject they would like to do since this has an effect on their performance. When someone considers what subject to do, preference should be given to what they like than what they do not like. There should be more provision of variety of subject to choose from to increase the permutations of students doing what they like.

8. The study shows that student ambition is an important factor in performance. Students should be encouraged to set targets and see themselves successful than failures in order to put effort towards the challenge. It is important to nurture students such that they can have self-esteem which will in turn build their confidence in learning. The aspect of acquisition of knowledge should at the end make a confident individual who can interact with others, take responsibility and demand accountability.

9. Contextual factors were found to be associated with performance. The learners' specific factors that were found to be important for academic performance were mainly concerned with learners' attitude and perception towards learning in general. Thus for effective learning to take place and performance improve, schools should concentrate on ensuring that all students are engaged in meaningful learning activities. And students should feel free and

safe during the learning process hence putting in place mechanism that would prevent such instances as bullying by other learners.

10. It has been established that some region performances were extremely far below the national mean performance. Thus such regions need more resources than those performing above the country's mean. This calls for resource allocation to be differentiated.

11. The majority of the school heads were found to stay shorter than 5 years in the same school which adversely affected implementation of their strategic plans. School heads should therefore be allowed to stay longer in one school before they are transferred to another school.

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APPENDICES

APPENDIX 1: Parental Involvement Variables

Item Loading	Questionnaire	Item No.
What is your age?	Parent	3
What is your marital status?	Parent	2
What type of house do you live in?	Parent	6
Does the compound you live in have the following amenities?	Parent	7
Do you own the following in your compound?	Parent	8
Do you own the following household goods in your compound?	Parent	9
What is your main source of income?	Parent	10
Father's highest education level.	Parent	16
Mother's highest education level.	Parent	17
Approximately what percentage of students in your school have the following backgrounds?	School	3
How many digital information devices are there in your home? Count computers, tablets, smartphones, smart TVs, and e-readers. (Do not count other devices.)	Student	5
Do you have any of these things at your home?	Student	6
What does your child do after school hours?	Parent	12
Do you spend money in any of the following for your child in Form 2?	Parent	13
How often do you participate in school activities concerning your Form 2 student?	Parent	19
How often do you discuss the progress of your child with the Mathematics or Science teacher?	Parent	20
How often do you discuss schoolwork with your child?	Parent	21
During the last 12 months, have you attended extra lessons or tutoring not provided by the school in the following subjects? For how many of the last 12 months have you attended extra lessons or tutoring?	Student	26A & B