TIMSS

ITEM DIAGNOSTIC REPORT: SOUTH AFRICA

GRADE 5 NUMERACY

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2030 NDP

The Human Sciences Research Council (HSRC) released the results of the 2015 Trends in International Mathematics and Science Study (TIMSS) on 29 November 2016. TIMSS is a cross-national assessment of the mathematics and science levels of learners from the various participating countries. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) to allow participating nations to compare learner educational achievement across borders.

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Preface

The Trends in International Mathematics and Science Study (TIMSS) is a four-year project. The 2015 TIMSS was carried out by the Education and Skills Development research programme of the Human Sciences Research Council under the direction of Dr Vijay Reddy. The study was funded by the Department of Basic Education.

This TIMSS Item Diagnostic report is one of three educator resource documents. The three reports contain diagnostic analyses of Grade 9 Mathematics TIMSS items; Grade 9 Science TIMSS items and Grade 5 Numeracy TIMSS items. Two reports containing the highlights of the Grade 5 and 9 TIMSS results have also been published. These documents, together with additional resources, are available on the TIMSS SA website: www.timss-sa.org.za.

The authors would like to state their appreciation towards the Department of Basic Education for allowing access to learners in the school system in this way and all the individuals who assisted in the construction of this report through their valuable insight and comments during the course of two workshops.

We hope that this report will further develop the capacity of our educators to benefit our learners in achieving their potential, thereby contributing to the science and innovation system, world of work and societal well-being in the longer term.

This TIMSS Item Diagnostic report was compiled by Dr Andrea Juan, Ms Sylvia Hannan, Ms Ncamisile Zulu, Ms Jaqueline Harvey, Dr Casper H Prinsloo, Professor Mogege Mosimege and Ms Unathi Beku.

Dr Vijay Reddy
Principal Investigator of TIMSS, South Africa

How can TIMSS 2015 help mathematics educators and learners?

This document seeks to answer that question and is best described as an **educator resource document**. It draws conclusions from the TIMSS 2015 Grade 5 Numeracy assessment results to show common learner strengths and weaknesses and makes recommendations. It acts as a supplement and is designed to assist educators and Department of Basic Education (DBE) officials. The educator resource document is organised into separate sections.

How do I use this document?

This document can be used by all educators, although it is specifically about Grade 5 learners. It does not replace or contradict any official DBE policies or documents, particularly those related to assessment and the delivery of the intended curriculum. When an educator or DBE official receives this resource document, an easy way to navigate it is through the steps below. This sequence of steps has been outlined to assist educators in helping their learners and/or assist DBE officials in their mentoring, coaching, training and support of educators.

STEP 01
- Scan the table of contents to familiarise yourself with the document

STEP 02
- Work through the summarised causal factors
- These factors were listed because they contribute to learner achievement on almost all items

STEP 03
- Work through the overall strengths and weakness
- Think about how these affect your learners and your teaching

STEP 04
- Work through the item-by-item analysis
- Item information is sequenced by strand and topic, in that order
- Both multiple-choice and free-response (open-ended) items are reported

STEP 05
- Work through the remedial recommendations
- Think about which recommendations are under your control, which ones you can refer to other agents, and which ones are outside of your control

STEP 06
- Based on the item-by-item analysis, identify and pursue remedial actions specific to your learners and your school
- This can be at the individual, item, or topic level

The contents page and rest of the document now follows. We hope that you find it informative and useful in teaching and assessment.

Contents

1. Introduction and background

The Trends in International Mathematics and Science Study (TIMSS) is an assessment of the mathematics and science knowledge of fourth[1] grade and eighth[2] grade learners around the world. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) to allow participating nations to compare learners' educational achievement across borders. TIMSS was first administered in 1995, and every four years thereafter. Fifty-nine countries and 425 000 learners around the world participated in TIMSS 2015.

TIMSS Numeracy was introduced in 2015 as an alternative to TIMSS Mathematics. The former is designed to assess mathematical knowledge and abilities at the end of the primary school cycle (Grades 4, 5 or 6) in countries where many learners are still developing fundamental mathematics skills. TIMSS Numeracy assesses fundamental mathematical knowledge, procedures, and problem-solving strategies that are prerequisites for success in TIMSS Mathematics assessments. TIMSS Numeracy asks learners to answer questions and work problems similar to TIMSS Mathematics, except with easier numbers and more straightforward procedures. Seven countries participated in TIMSS Numeracy in 2015: Bahrain, Indonesia, Iran, Jordan, Kuwait, Morocco and South Africa (Mullis & Martin, 2013).

The Human Sciences Research Council (HSRC) conducted TIMSS Numeracy in South Africa in 297 schools among 10 932 Grade 5 learners. Participating in TIMSS assessments provides important information for a country's policy makers about the state of mathematics and science education and what is required for improving the quality of education. The assessment results therefore provide the data necessary for monitoring and evaluation, from which recommendations can be made to improve the health of a country's education system. For South Africa, the easier formulation of the TIMSS Numeracy items will allow for greater differentiation in learner achievement so that policy makers and other stakeholders can accurately establish learner strengths and weaknesses. In addition, the assessment of prerequisite skills for mathematics will also provide information regarding the readiness of learners for more cognitively challenging content as they progress in their academic trajectories. As this is the first time that South Africa has participated in TIMSS Numeracy, this assessment serves as a baseline against which future results at the Grade 5 level may be compared.

In order to facilitate comparison across countries and over time, TIMSS data are scaled to an international centre point (500) and standard deviation (100). This means that a score of 500 reflects the midpoint for all TIMSS country average scores. The TIMSS approach to scaling the achievement data is based on item response theory (IRT), which in turn is based on psychometric models, with marginal estimation. Through this methodology it is possible to include South Africa (TIMSS Numeracy) on the same scale as the countries that participated in the full TIMSS assessment at the Grade 4, 5 or 6 level.

The current report is intended to provide educators, subject advisors, curriculum planners and education officials with insight into Grade 5 learners' performance in the Numeracy assessment by exploring performance on individual items. The report will aim to improve planning at all levels of the education system through the provision of reliable and relevant information.

[1] *Learners may also participate at the Grade 5 or 6 level.*
[2] *Learners may also participate at the Grade 9 level.*

The key research questions that will be answered are:

1. How did the learners perform on each item?
2. Which part of the South African curriculum does each item fit into?
3. What cognitive processes are required to answer each numeracy question correctly?
4. What types of errors have learners made in answering numeracy questions?
5. What action is recommended to remediate the problems identified?

The above questions were answered through a detailed analysis of learners' responses to each of the TIMSS Numeracy items that were released to the public by the IEA, with the focus of the analysis being both qualitative and quantitative. The following section of the report explains the TIMSS Assessment Framework in relation to the content and cognitive domains which are addressed in TIMSS Numeracy, as well as how the latter is designed to align with the school curriculum. This section provides an overview of South African Grade 5 learner performance, as well as learner achievement by the three content areas and cognitive domains.

Section four, which forms the main part of the report, presents the diagnostic item-by-item analysis of each of the released 23 items for TIMSS Numeracy. This was conducted by the research team to identify the content knowledge and skills that learners were able or not able to use to demonstrate their answers. Items include both closed-ended (multiple-choice questions) and open-ended questions. For the analysis, a random sample of 50 learner responses to each item was taken from the original test booklets and experts in mathematics teaching were consulted to verify interpretations and findings. Each item is presented in terms of learner achievement, the relevant content and cognitive domain in which it fits, and the location of the item content in the South African Grade 5 curriculum. In order to understand where learners experience problems in answering specific items, common types of errors are identified and recommended actions for addressing problem areas are suggested for each item.

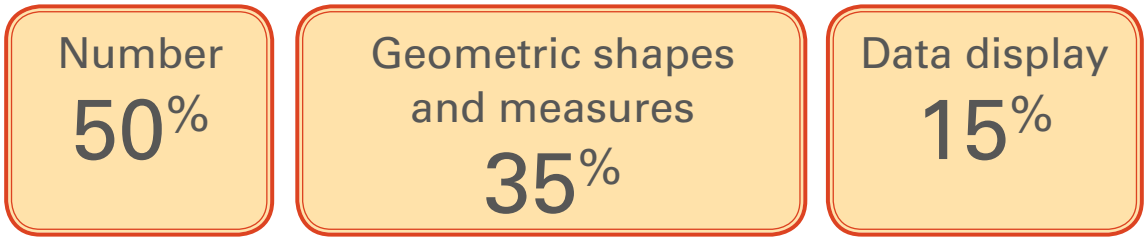
The analysis provided a clear indication of the weaknesses in learner responses and illustrated possible knowledge "gaps" and common misunderstandings that need to be addressed. Uncovering misconceptions or error patterns in the learner responses can directly inform instructional practice and therefore, in response to the weaknesses identified, the report suggests remedial measures that should be adopted at school level. This will allow educators to review and refine their teaching strategies accordingly.

The results and data from this process were presented during three working meetings with curriculum and assessment specialists from the DBE, nationally and provincially. This report reflects the outcome of this process.

2. TIMSS assessment framework

Content domains/strands

Three content domains or strands are covered in TIMSS at the fourth or fifth grade level[3]: Number; Geometric shapes and measures; and Data display. Each domain specifies the subject matter to be assessed and requires learners to demonstrate a certain range of knowledge and skills. Each content domain consists of topic areas, and each topic area includes several sub-topics. The figure below shows the three content domains and the target percentages of the assessment devoted to each.



Number

The number content domain consists of understandings and skills related to three topic areas:

1. Whole numbers
2. Fractions and decimals
3. Expressions, simple equations, and relationships

Twenty five percent of the 50% devoted to this content domain focuses on whole numbers, 15% focuses on fractions and decimals, and the remaining 10% is devoted to expressions, simple equations, and relationships.

As working with whole numbers provides the foundation of mathematics in primary school, this topic forms a predominant component of the Number domain. In addition, it is important for learners to understand fractions as a basis for calculations as objects and quantities are often not in whole numbers. Finally, pre-algebraic concepts such as understanding the concept of variables (unknowns) in simple equations, and initial understandings of relationships between quantities are included in the assessment.

Geometric shapes and measures

Geometry enables learners to visualise and understand the relationships between shapes and sizes. This content domain focuses on understanding measurements, the coordinate plane, lines, and angles, as well as covering surfaces and solids. There are two topic areas in geometric shapes and measures:

1. Points, lines, and angles
2. Two- and three-dimensional shapes.

Learners should be able to identify the properties and characteristics of lines, angles, and a variety of geometric figures, including two- and three-dimensional shapes. Learners will also be expected to be able to draw a range of geometric figures, as well as to analyse geometric relationships and use these relationships to solve problems. The use of instruments and tools to measure physical attributes such as length, area, angle, and volume; and simple formulas to calculate areas and perimeters of squares and rectangles is also required.

[3] *See: Mullis, I.V.S. & Martin, M.O. (Eds.). (2013). TIMSS 2015 Assessment Frameworks. Retrieved from http://timssandpirls.bc.edu/timss2015/frameworks.html for more detail on the assessment framework.*

Data display

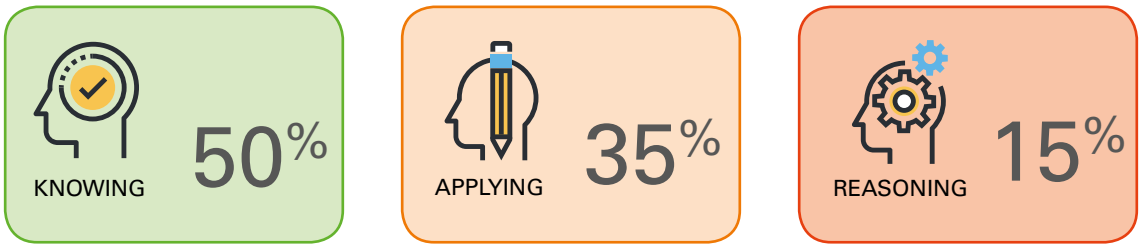
Learners need to understand that graphs and charts help organise information or categories and provide a way to compare data. The data display content domain consists of one topic area:

1. Reading, interpreting, and representing

At this level, learners should be able to read and recognise various forms of data displays, such as tables, pictographs, bar graphs, line graphs and pie charts. Learners should be able to organise and represent data in graphs and charts in relation to a simple problem situation and the data that have been collected. In addition, they should know how to compare characteristics of data and draw conclusions based on data displays.

Cognitive domains

In order for learners to correctly complete the TIMSS test items they need to draw on a range of cognitive skills. These skills are addressed by TIMSS Numeracy in terms of three cognitive domains. The figure below identifies the three cognitive domains and the target percentages of the assessment devoted to each. The questions which were asked in TIMSS Numeracy included items developed to address each of these domains.



The first domain, **Knowing**, encompasses the facts, concepts and procedures that learners need to have as a foundational knowledge base. This enables recall of the language and basic facts and conventions of numbers, symbolic representation, and spatial relations. In addition, this knowledge facilitates the application of mathematics and reasoning about mathematical situations.

The second domain, **Applying**, focuses on learners' ability to apply knowledge and conceptual understanding of mathematics to solve problems or answer questions. In this domain, the facts, concepts and procedures, as well as the problems, should be familiar to the learners. Central to this domain is problem solving, with an emphasis on more familiar and routine tasks. Problems may be set in real-life situations, or may be concerned with purely mathematical questions.

The final domain, **Reasoning**, extends beyond the solution of routine problems to include unfamiliar situations, complex contexts, and multi-step problems. This domain requires learners to think logically and systematically, and questions may be purely mathematical or have real-life settings.

[4] *The South African Curriculum Assessment Policy Statement (CAPS) for the intermediate level includes four cognitive levels: knowledge, routine procedures, complex procedures and problem solving.*

Curriculum

TIMSS is designed to align broadly with intended mathematics curricula in the participating countries. The results, therefore, suggest the degree to which learners have learned mathematics concepts and skills likely to have been taught in school. TIMSS also collects background information on the participating learners, educators and schools to allow cross-national comparison of educational contexts that may be related to student achievement. TIMSS uses the curriculum as the organising principle of how educational opportunities are provided to learners. The curriculum model consists of three aspects: (i) the intended curriculum, (ii) the implemented curriculum and (iii) the attained curriculum.

(i) Intended curriculum

The intended curriculum identifies the percentage of the TIMSS Grade 5 assessment topics that were covered in the CAPS curriculum in either Grade 3, 4 or 5. The topics included in the assessment of geometric shapes and measures, and data display had been fully covered by Grade 5. The majority of topics within the number content domain had also been covered.

(ii) Implemented curriculum

To interrogate the performance in specific content areas, Tables 1, 2 and 3 set out the percentages covered of each TIMSS topic before, during and after Grade 5. This is based on educator reports of what was covered at the time of assessment. The percentages reflect the proportion of learners who were taught these topics.

Table 1: Coverage of Number topics as reported by educators (% learners taught)

Topic	Mostly taught before this year	Mostly taught this year (Grade 5)	Not yet taught or just introduced
(a) Concepts of whole numbers, including place value and ordering	65,8	34,2	0
(b) Adding, subtracting, multiplying, and/or dividing with whole numbers	64,3	35,7	0
(c) Concepts of multiples and factors; odd and even numbers	45,7	53,5	0,8
(d) Concepts of fractions (fractions as parts of a whole or of a collection, or as a location on a number line)	48	51,4	0,6
(e) Adding and subtracting with fractions, comparing and ordering fractions	42,4	55,9	1,7
(f) Concepts of decimals, including place value and ordering, adding and subtracting with decimals	22,5	47,3	30,2
(g) Number sentences (finding the missing number, modelling simple situations with number sentences)	44,1	53,6	2,3
(h) Number patterns (extending number patterns and finding missing terms)	48,7	50,6	0,8

Table 2: Coverage of geometric shapes and measures topics as reported by educators (% learners taught)

Topic	Mostly taught before this year	Mostly taught this year (Grade 5)	Not yet taught or just introduced
(a) Lines: measuring, estimating length of; parallel and perpendicular lines	18,2	49,6	32,3
(b) Comparing and drawing angles	12,5	56	31,5
(c) Using informal coordinate systems to locate points in a plane	33,2	50,6	16,2
(d) Elementary properties of common geometric shapes	33,6	53,6	12,8
(e) Reflections and rotations	23,9	70,0	6,1
(f) Relationships between two-dimensional and three-dimensional shapes	32,1	63,9	4,0
(g) Finding and estimating areas, perimeters, and volumes	17,4	58,4	24,2

Table 3: Coverage of data display topics as reported by educators (% learners taught)

Topic	Mostly taught before this year	Mostly taught this year (Grade 5)	Not yet taught or just introduced
(a) Reading and representing data from tables, pictographs, bar graphs, or pie charts	43,7	54,7	1,6
(b) Drawing conclusions from data displays	34,3	57,5	8,2

(iii) Overview of learner performance (attained curriculum)

TIMSS Mathematics items are designed to measure learner knowledge and proficiency, which can range widely from one learner to another. The TIMSS benchmarks attempt to provide more meaningful descriptions of what learners know. South African learners scored an average of 376 points. According to the TIMSS categorisation, approximately two-fifths of learners (39%) achieved above the 400 TIMSS point mark. That is, three-fifths of South African learners (61%) do not exhibit the minimum competences in basic mathematical knowledge required at the Grade 5 level (Reddy et al., 2016).

Performance by content and cognitive domains

TIMSS covers specific content domains for each grade, which are designed to test the knowledge and skills of learners in relation to a number of specific topics. Grade 5 learners were tested on three content domains: numbers, shapes and measures, and data display. Learners performed slightly better than the overall mean in the Number content domain (by 3 points). This is reflected in the high proportion of learners who were taught the various topics (Table 1) either in Grade 5 or in earlier grades. The exception is topic f: concepts of decimals, including place value and ordering, adding and subtracting with decimals; which, according to CAPS is only introduced to learners in Grade 6. Interestingly, according to the educators, 69.8% of learners had been exposed to decimals at the time of assessment.

Learners performed 16 points below the overall average in the Geometric shapes and measures content domain. This again reflects the reported coverage of the specific topics, as educators reported that some topics had not been covered at the time of the testing (Table 2).

Coverage of data display was high, as shown in Table 3. Learners performed slightly higher than the overall average in this content area (by 5 points).

Knowing, applying and reasoning are the hierarchical order of cognitive demand. In South Africa, learners are performing at a level similar to the overall country average in terms of knowing and applying their mathematical knowledge, but perform lower with respect to their reasoning skills (by 7 points).

Table 4: Learner performance by content and cognitive areas

	% of assessment	Mean	SE*	Difference from overall mean
Content domain:				
Numbers	50%	379	(3,4)	+3
Geometric shapes & measures	35%	359	(3,7)	-16
Data display	15%	381	(4,0)	+5
Cognitive domain:				
Knowing	50%	378	(3,6)	+2
Applying	35%	377	(3,4)	+1
Reasoning	15%	369	(3,5)	-7
Overall	100%	376	(3,5)	

** Standard Error: a measure of the statistical accuracy of an estimate.*

Table 5 provides a summary of the intended (covered by CAPS up to Grade 5), implemented (educator reports) and attained curriculum (learner average achievement).

Table 5: The intended, implemented and attained curriculum

	Covered in CAPS in previous grades or grade 5	Mostly taught before this year/ this year (Grade 5)[1]	TIMSS average achievement score
	Intended	Implemented	Attained (difference from average score)
Numbers (8 topics)	87,5%	95,5%[2]	379 (+3)
Geometric shapes and measures (7 topics)	100%	81,9%	359 (-16)
Data display (2 topics)	100%	95,1%	381 (+5)

[1] *Educator reports of what had been taught at the time of testing.*
[2] *Although "concepts of decimals" is not covered in the CAPS document, educators did report teaching the topic. This accounts for the higher percentage of implemented curriculum.*

3. Overarching factors and remedial actions

This diagnostic report is somewhat limited by the small pool of released TIMSS items that could be analysed; however, there are a number of general observations that can be made. It is also noted that these observations are presented individually, but influence and are dependent on one another systemically. Therefore, rectification of one factor will require improvement in others as well.

Language proficiency is weak

Items with long problem statements were problematic for South African learners. This may be due to poor reading and writing proficiency leading learners to skim items and misunderstand the item in general, only focusing on information salient to them as the answer. As an example, learners seem to have only taken instructions from the first few words in a problem statement. Language deficiencies also hamper learners in expressing themselves. Beyond simple grammar and spelling, educators may not have explicitly taught learners how to logically formulate an answer and present their thinking.

Foundational reading and writing skills are therefore not at an appropriate level, which may stunt learners' academic development. Difficulties in both receptive and expressive language may be related to English and/or Afrikaans being second languages for the majority of learners. In addition, educators need to be aware that there are synonyms for some concepts which need to be covered and require the educator to be well-versed in the content themselves.

Furthermore, mathematics is in itself a language and educators should emphasise this in their teaching. Some of the mathematical language and terminology that South African learners have difficulty understanding are terms such as "and", "of", "greater than" and "less than", among others. Another example of unfamiliarity with language and terminology could be seen from the use of the word "other than", which seemed to confuse the learners and resulted in the selection of incorrect responses.

Remedial action

- There needs to be a focus on improving learners' reading and writing skills.
- Educators should familiarise themselves and their learners with the range of mathematical language and terminology.
- Learners require focused instruction on translating word problems utilising unfamiliar phrases (such as those identified) into their numerical and symbolic mathematical terms.
- Learners need to be taught how to read questions in their entirety and identify relevant information with which to work.
- Learners need to be taught how to logically formulate an answer and present their thinking.

Foundational skills are lacking

During analysis of the items, it was found that South African learners struggle with basic mathematical concepts that should have been covered (and consolidated) in earlier grades. This is concerning as a strong foundational knowledge base is essential for progression through academic studies as each concept is strengthened and built upon. Furthermore, once learners have automated basic number operations, such as addition and subtraction, they are then at a stage where they can identify and work with the deeper underlying principles.

On several items, learners immediately began to perform the simpler calculations with the superficial information presented to them within the problem statement and/or diagram. However, this resulted in incorrect answers when what was required was the understanding of the more complex principle that indicates when and how to apply such calculations. This could point to teaching challenges within the foundation phase of the schooling system. Due to the prescribed curriculum that needs to be covered in the year, it is clear that some educators are not able to adequately, or to a greater extent, do revision of some of the concepts which were covered in earlier grades. This is evident in the performance of the learners in those mathematics topics that are prescribed in the earlier phases

Remedial action

- Educators need to revise some of the concepts which are covered in earlier grades to ensure that all learners have the foundational knowledge with which to move forward.
- Learners need to be provided with practice examples of problems which require deeper analysis.
- Educators should give learners examples to work with, after which they can provide feedback and support to learners.

Higher order problem solving skills and abstract thought must be emphasised

It is evident from a number of questions that it is imperative that learners know how to reason in order to obtain the correct answer. This links to the solidification of foundational concepts and skills. Once learners are able to perform relatively simple calculations, they will be better able to use them as a tool during problem solving.

Remedial action

- The curriculum specialists together with the educators need to focus on integrating reasoning skills into teaching methodologies.

Exam and testing techniques need attention

TIMSS studies comprise a large component of multiple-choice questions, and errors in the learners' responses indicate that they need to be taught how to answer these types of questions. In other words, learners might possibly have made different choices if they had been shown how to strategise when answering multiple-choice questions. In addition, learners do not appear to draw conclusions from all information in open-ended questions.

Remedial action

- Learners need to be taught strategies for answering multiple-choice questions.
- Learners need to be taught to draw conclusions from all information given in open-ended questions, both explicit and implicit

Educator training in the foundation and intermediate phases is crucial

Furthermore, assessment techniques relate to the skills of the educator to (i) present question type and phrasing variations, (ii) expose learners to figures, graphs, tables and diagrams, (iii) work with learners from diverse backgrounds, foundational knowledge and home language, and (iv) show learners how to work with the information presented in a meaningful manner.

ACTION

All four abilities require a highly sophisticated educator and therefore educator training in the foundation phase should be highlighted and acknowledged as a crucial aspect of ensuring educational success.

4. Item-by-item analysis

In this section, a statistical item analysis of each released item (23) for TIMSS Numeracy is presented. The questions are grouped according to the TIMSS content area they are designed to assess. Values given for each item response within the tables are presented in percentages.

For the multiple-choice questions, a comparison is made across item response selection for South African learners as well as with regard to the international standard. The correct answer for the multiple-choice questions is highlighted in the tables. For analysis of the open-ended questions, a comparison will be made with the marking memorandum. Both types of questions will be discussed in terms of the South African curriculum, the cognitive processes involved and the type of errors made; and recommendations to address learner misconceptions based on the foregoing.

When conducting the quantitative and qualitative analysis of each item, it was noted that there are overarching factors that are influential in many items. These factors are discussed in section 3 with regard to: conceptual gaps, factual errors, and knowledge-processing anomalies among learners, as well as to suggestions for required remedial action. Caution must be exercised in generalising the interpretations of this report due to the small number of items that have been released.

TIMSS content area: Whole numbers

Cognitive domain	*TIMSS: Knowing*	*CAPS: Routine procedure*

QUESTION 1

N01_03

447
+ 232
+713

A. 1 492
B. 1 482
C. 1 392
D. 1 382

Learner performance

	A	B	C	D	Omitted
South Africa	12	14	**58**	14	2
International average[5] (n=7)	10	10	**66**	10	3

South African curriculum

This question fits into the part of the Grade 5 South African curriculum which covers numbers, operations and relationships. Learners are expected to be able to complete addition and subtraction of whole numbers of at least 5 digits. This content area is also taught at the Grade 4 level. The question requires learners to be able to recognise the value of each digit in a three-digit number, and solve vertical addition problems.

[5] *Seven countries, including South Africa, took part in TIMSS Numeracy.*

Error analysis

Most learners were able to answer the question correctly. Those who chose options A, B or D have made errors in addition (using place holders) or have merely guessed the answer.

Learners may have had problems with the question as they are taught to solve addition sums horizontally rather than vertically (447+232+713).

Cognitive domain *TIMSS: Knowing* *CAPS: Problem solving*

QUESTION 2

A store has 10 boxes of juice. Each box holds 6 cans of juice. How many cans of juice does the store have?

Answer: _____ cans

N01_03

Learner performance

	Correct	Incorrect	Omitted
South Africa	31	67	1
International average (n=7)	46	48	6

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships. Learners are taught to complete addition, subtraction, multiplication and division with whole numbers. Learners should be able to undertake division of at least whole 3-digit by 2-digit numbers, which is a curriculum component that is covered in both Grade 4 and Grade 5. In order to answer this question correctly, learners need to be able to read and interpret word problems, and determine the appropriate calculation technique required.

Error analysis

Learners answering 16, instead of the correct answer of 60, was the most common incorrect response. This might be because the learners did not read the question correctly and may have thought it was an addition question instead of multiplication. When in doubt, learners may have the tendency to revert to addition to solve a problem.

Applying addition methods in this case could also be a result of learners misunderstanding that a given unit (i.e. the box) can be composed of a collection of smaller units (i.e. the cans). This is an important principle that would, if grasped correctly, assist learners in understanding fractions.

Other common incorrect answers were 6 and 4 where: 6 could have been taken from the question and 4 was obtained by subtracting 6 from 10, which were the two numbers presented in the story sum. Learners were thus not able to understand what was required from the question.

Item-by-item analysis (continued)

Figure 1: Example of a correct answer where learner has drawn the number of cans and grouped them

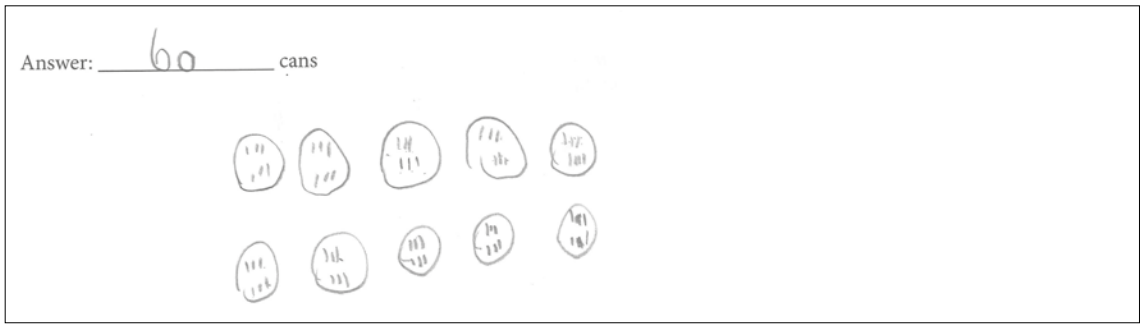
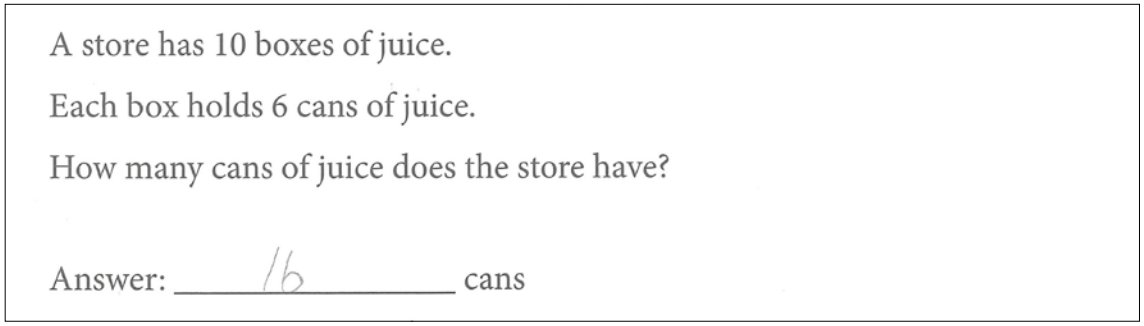


Figure 2: Example of an incorrect answer where learner has added the numbers in the question together



Cognitive domain	*TIMSS: Knowing*	*CAPS: Routine procedure*

QUESTION 3

N01_04

$36 \div 2 =$

A. 13
B. 18
C. 34
D. 38

Learner performance

	A	B	C	D	Omitted
South Africa	19	**51**	12	16	2
International average (n=7)	16	**57**	12	10	5

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships. In Grade 5, learners are taught to complete addition, subtraction, multiplication and division with whole numbers. Learners should be able to undertake division of at least whole 3-digit by 2-digit numbers. This is also taught in Grades 3 and 4. Learners need to understand how to solve division problems, and how to check their answers, allowing them to select the correct answer from the options provided.

Error analysis

Learners who chose option A have used division procedures but applied them incorrectly. Those learners who selected option C have subtracted the numbers, and those who selected option D have added the numbers together.

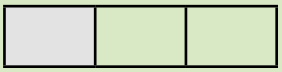
Cognitive domain *TIMSS: Knowing* *CAPS: Knowledge*

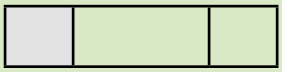
QUESTION 4

N01_07

Which rectangle is 1/3 shaded?

A. 

B. 

C. 

D. 

Learner performance

	A	B	C	D	Omitted
South Africa	3	61	7	23	7
International average (n=7)	6	64	7	18	5

South African curriculum

This fits into the part of the South African curriculum which teaches calculation techniques and solving problems. Learners are expected to solve problems in contexts involving common fractions, including grouping and sharing. This component of the curriculum is covered in Grade 4 and Grade 5 where learners are taught to compare and order common fractions and solve problems in common fractions. In order to answer this question, learners need to understand fractions, and be able to recognise fractions in diagrammatic form.

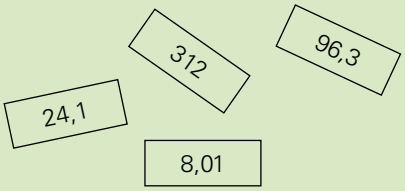
Error analysis

This question was answered relatively well, with 3 out of 5 learners answering correctly. However, learners who incorrectly selected option D did not show understanding of what constitutes a numerator and a denominator. Learners who selected option C did not show knowledge that fractions of a whole must be equal in size.

Item-by-item analysis (continued)

Cognitive domain *TIMSS: Knowing* *CAPS: Knowledge*

QUESTION 5



Write the numbers above in order from **smallest** to **biggest**.

_____ _____ _____ _____

Smallest Biggest

N01_08

Learner performance

	Correct	Incorrect	Omitted
South Africa	34	66	0,7
International average (n=7)	25	70	5

South African curriculum

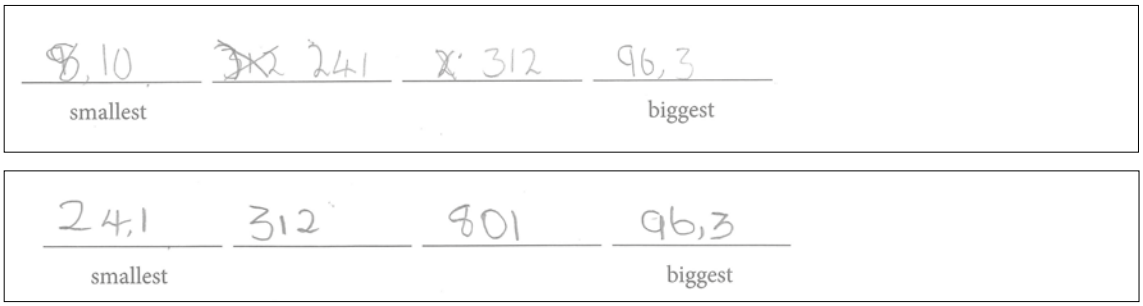
This question fits into the part of the South African curriculum which covers numbers, operations and relationships. Learners are expected to be able to order at least 6-digit numbers. However, decimals are only covered in Grade 6. Answering this question involves learners being able to recognise the smallest and biggest numbers, understanding the relevant mathematical vocabulary such as "smallest" and "biggest", and being familiar with decimal fractions.

Error analysis

Three types of number patterns were observed from the qualitative analysis:

- Number patterns of 24,1; 312; 8,01; 96,3 were found, where the learners looked at the first digit of each number when arranging it from smallest to biggest and did not pay attention to decimals. There is therefore no understanding of decimals and the role that they play.
- Another pattern noted was: 8,01; 24,1; 312; 96,3. In this case, it appears that learners have rewritten the numbers from the bottom of the page to the top of the page (as indicated in the item excerpt above). As this content has yet to be covered, this is most likely their best "guess" of what the question was asking.
- The final pattern most noted was 312; 8,01; 24,1; 96,3. The thought processes behind this selection are unclear.

Figure 3: Examples of incorrect answers



Cognitive domain *TIMSS: Knowing* *CAPS: Routine procedure*

QUESTION 6

$43 \div 5 =$

N04_01

Learner performance

	Correct	Incorrect (8)	Incorrect (Other)	Omitted
South Africa	21	11	67	2
International average (n=7)	17	16	60	7

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships. Learners are taught to complete addition, subtraction, multiplication and division with whole numbers, which is covered in Grade 5. Learners should be able to undertake division of at least whole 3-digit by 2-digit numbers. This is also taught in Grade 4. Learners need to understand division problems to answer this question.

Error analysis

The correct answer for the question was 8 with a remainder of 3 OR $8\frac{3}{5}$ or equivalent. Eleven percent of learners gave an answer of 8 for the question. This indicates that these learners are able to work with whole numbers, but are not familiar with using fractions or working out remainders. Sixty-seven percent of learners gave other incorrect responses. This included answers between 7 and 12 (excluding 8), which may have resulted from learners using the correct procedure (division), but calculating the answer incorrectly. Other learners appeared to calculate their answers using other procedures, such as addition, subtraction or multiplication

Item-by-item analysis (continued)

Figure 4: Example of correct answers

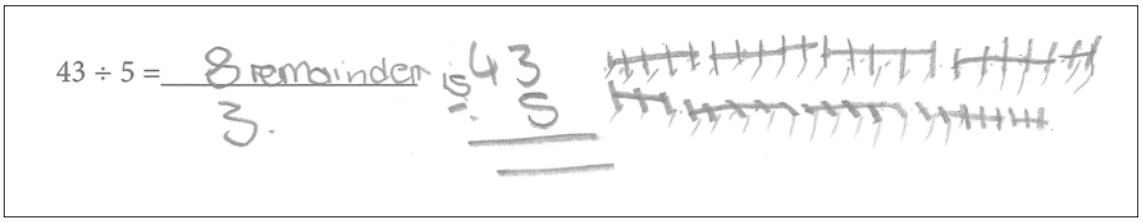


Figure 5: Example of an incorrect response where the learner performed a multiplication sum

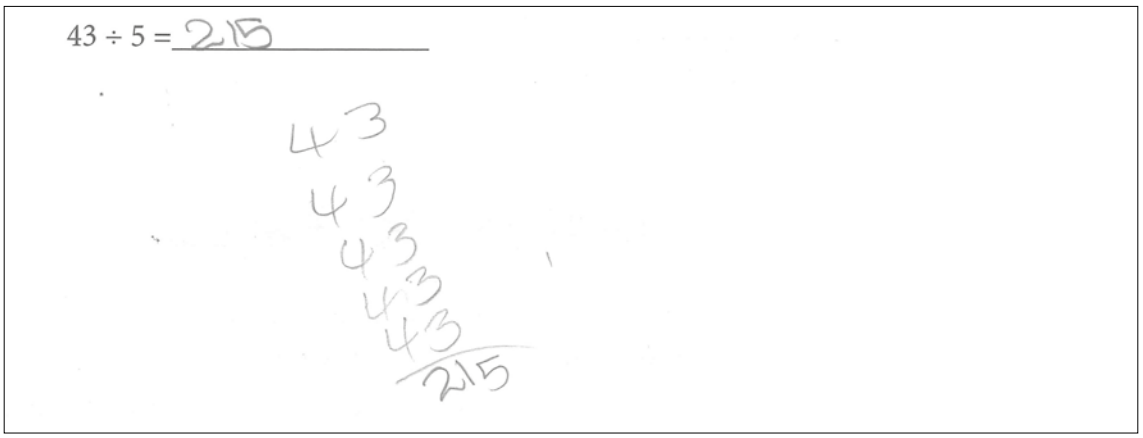
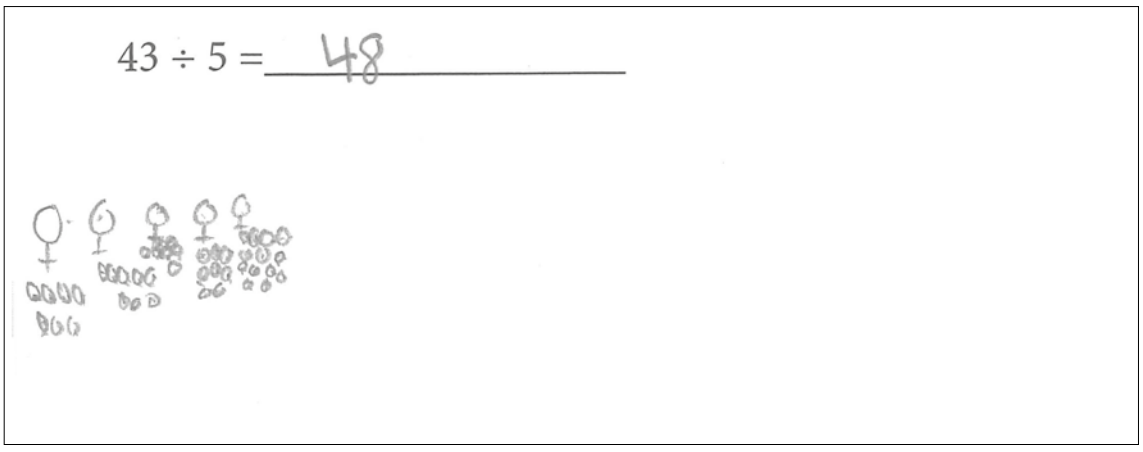


Figure 6: Example of an incorrect response where the learner performed an addition sum



Cognitive domain *TIMSS: Knowing* *CAPS: Complex procedure*

QUESTION 7

Josh is rounding off numbers to the nearest 100.

A. Write a number for Josh that is less than 200 and rounds to 200.

Answer:_____

B. Write a number other than 500 that is more than 200 and rounds to 500.

Answer:_____

N04_02

Learner performance

	Both correct	Part A correct	Part B correct	Incorrect	Omitted
South Africa	11	7	6	75	0,4
International average (n=7)	22	10	4	58	6

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships. Grade 5 learners are taught to work with whole numbers and are expected to be able to order, compare and represent numbers to at least 6-digit numbers, as well as to round off to the nearest 5, 10, 100 and 1 000. This area is also covered in the Grade 4 curriculum (order, compare and represent numbers to 3-digit to 4-digit numbers, as well as to round off to the nearest 5, 10, 100 and 1 000). To answer this question, learners need to understand the concept of rounding off, as well as estimation. They must also be familiar with the mathematics vocabulary: nearest, more than, less than, other than.

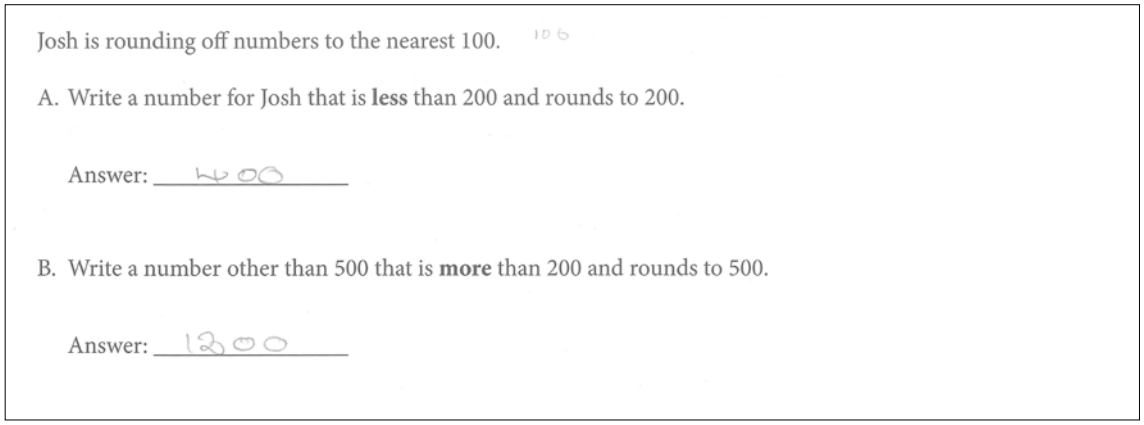
Item-by-item analysis (continued)

Error analysis

The correct answer for Part A of the question was any number from 150 to 199 (including 150 and 199). Two common errors were identified in the sample. Some learners answered 100. These learners may have focused on the first part of the question, which states that Josh is rounding off to the nearest 100. Alternatively, these learners may have subtracted or rounded down by 100, as Part A of the question referred to a number "less than" 200. The other common error which was found was learners adding together the two numbers (200+200) in Part A of the question to obtain an answer of 400.

For Part B, the correct answer was any number from 450 to 549 (including 450 and 549). One of the common errors made by learners was the same as the second error identified for Part A. Some learners added together either two or all three of the numbers in the question. Answers provided were therefore around 700 (500+200), 1 000 (500+500) or 1 200 (500+200+200). On the other hand, some learners provided an answer of 300, which they may have obtained by subtracting the first 2 numbers (500-200). Alternatively, these learners may have rounded up by 100 (as seen in Part A) to a number that was "more than" 200. Another error that was made by a few learners was answering 600 for Part B of the question. These learners may have taken the 500 from the question and added 100 as they misunderstood the meaning of rounding off to the neared 100.

Figure 7: Example of an incorrect answer where the learner added the figure together


Josh is rounding off numbers to the nearest 100.

A. Write a number for Josh that is **less** than 200 and rounds to 200.

Answer: 400

B. Write a number other than 500 that is **more** than 200 and rounds to 500.

Answer: 1200

KNOWING

Recommendations—Number

Language

- Learners must be taught how to read questions in their entirety and identify relevant information with which to work, as well as what specific action is required.
- Learners need to be exposed more regularly to mathematical items that include words, as they appear to perform better in items which have only numbers.

Fractions

- Fractions should be taught using concrete objects such as blocks so that learners are able to understand the concept.
- Familiar fractional analogies should then be used that the learners will immediately recognise, for example, a cake.
- Educators must ensure that every learner understands the distinction between a numerator and a denominator.

Back to basics

- Basic principles should be emphasised as these form the basis for understanding other concepts.
- Learners struggle with the basic mathematical procedure of "carrying over" that should have been covered in Grade 4. This requires consolidation of such procedures in the earlier grade, as well as the use of practice examples.
- Learners seem to struggle with basic mathematical procedures, such as division, that should have been covered in earlier grades and then built upon. This requires consolidation of such procedures in earlier grades and more practice examples included in teaching.

Consolidation of new concepts

- Learners are unfamiliar with working with remainders. This suggests that learners' classroom work should also incorporate variations of division problems which have solutions other than whole numbers.
- Learners do not understand how to interpret relationships between numbers or the meaning of rounding off to the nearest 100. When in doubt, learners often turn to simple arithmetic such as addition and subtraction of numbers. Learners should be exposed to different ways of answering questions as "rounding off" is not usually assessed in this manner. In addition, learners should be taught how to answer questions that have multiple parts.

Item-by-item analysis (continued)

Cognitive domain	*TIMSS: Applying*	*CAPS: Complex problem*

QUESTION 8

Write any number that

- is between 300 and 400 and
- has 8 in the tens place

Answer: _____

N01_02

Learner performance

	Correct (380 – 389)	Incorrect (301 – 379 or 390 – 399)	Incorrect (Other)	Omitted
South Africa	**18**	11	70	0,9
International average (n=7)	**29**	4	59	8

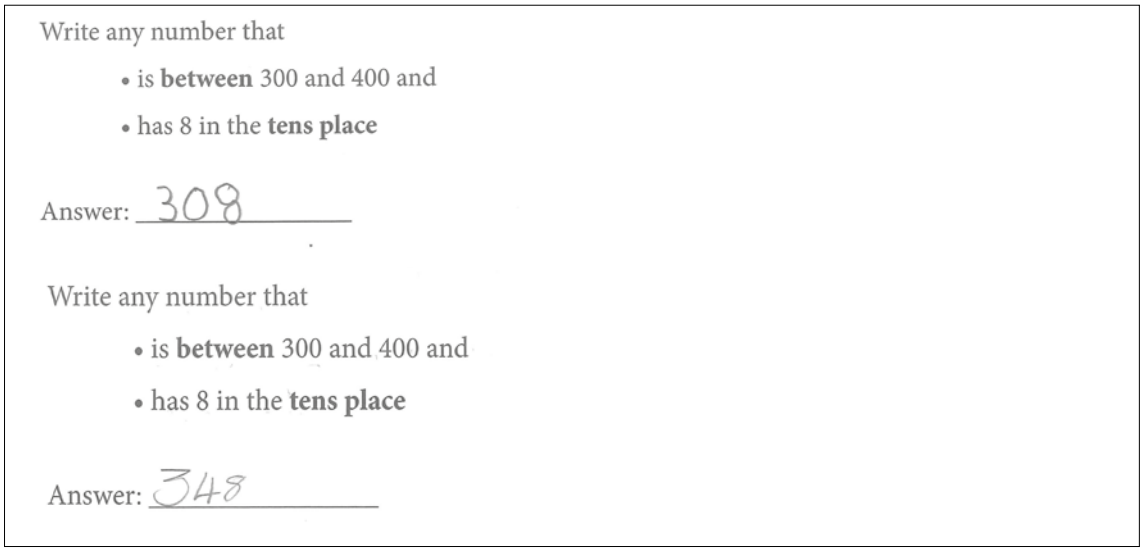
South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships. In Grade 5, learners are taught to order, compare and represent numbers to at least 6-digit numbers. They are also expected to recognise the place value of digits in whole numbers to at least 6-digit numbers. This component of the curriculum is covered in Grade 4 (4-digit numbers) and in Grade 5. Learners must understand place values of numbers to answer this question, and be able to consolidate the two sections of the question.

Error analysis

The majority of South African learners answered incorrectly (70%) while 11% of learners answered the question with any number from 301 to 399 without 8 in the tens place, thus not answering the second part of the question. This indicates that learners possibly struggled to understand the item with regard to language, did not sufficiently understand the principle of place value being tested, and/or did not recognise that there are two limits placed on their answers which must both be applied.

Figure 8: Examples of incorrect responses where learners have placed the 8 in the incorrect place


Write any number that

- is **between** 300 and 400 and
- has 8 in the **tens place**

Answer: 308

Write any number that

- is **between** 300 and 400 and
- has 8 in the **tens place**

Answer: 348

Cognitive domain	*TIMSS: Applying*	*CAPS: Routine procedure*

QUESTION 9

N01_05

Jane was counting by fours. She said: 8, 12, 16, 20. What number should she say next?

Answer: _____

Learner performance

	Correct	Correct with additional information	Incorrect	Omitted
South Africa	61	3	35	0,9
International average (n=7)	49	4	41	6

South African curriculum

This question fits into the part of the South African curriculum which covers patterns, functions and algebra. Learners should be able to investigate and extend numeric patterns looking for relationships or rules of patterns, including sequences not limited to a constant difference or ratio. Numeric patterns are covered in Grade 5 and Grade 4. For this question, learners must be familiar with number patterns, and must understand how to calculate the number which is being added to each number in the sequence, in order to identify the next number in the sequence.

Item-by-item analysis (continued)

Error analysis

Sixty-four percent of learners answered this question correctly. Sixty-one percent of learners provided the correct answer of 24, while 3% gave the answer of 24 and then continued the pattern beyond 24.

The incorrect answer of 28 was frequently given. The learners may have obtained this answer by counting in 8s (the first number given) and not reading the question properly. In these cases, 8 was added to the last number given, 20, to render an answer of 28.

Learners may have skimmed the item and misunderstood the item in general, only focusing on information salient to them as the answer.

Cognitive domain	*TIMSS: Applying*	*CAPS: Complex problem*

QUESTION 10

N01_06

Jabu had 16 peaches. He gave away 4 peaches. Then Jabu divided the remaining peaches equally between 2 baskets. How many peaches did Jabu put in each basket?

A. 6
B. 8
C. 10
D. 12

Learner performance

	A	B	C	D	Omitted
South Africa	**38**	13	16	32	0,9
International average (n=7)	**42**	12	12	31	4

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships. In Grades 4 and 5 learners are taught subtraction and division of whole numbers. To answer this question, learners must understand word problems, and how to identify what information is provided and what information is still required. They must also be able to identify the required calculation techniques.

Error analysis

Thirty-two percent of learners selected the incorrect answer D, which was 12. These learners may therefore have only read or followed the first part of the question, which stated that Jabu gave away 4 of his 16 peaches. Learners may also have skimmed the item and misunderstood the item in general, focusing only on information salient to them as the answer. Lastly, although "divided" and "equally" are used within the problem statement, learners may not have recognised this as a simple divide by 2 number operation. They may therefore have stopped after the first calculation.

Cognitive domain *TIMSS: Applying* *CAPS: Routine procedure*

QUESTION 11

Flowers for Sale by the Bunch

Irises	2,30 zeds
Roses	3,70 zeds
Tulips	4,20 zeds

Sarah bought one bunch of each type of flower. How much did she spend altogether?

Answer: _____ zeds

N01_12

Learner performance

	Correct	Incorrect	Omitted
South Africa	24	74	2
International average (n=7)	28	64	6

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships for Grade 5. Learners are expected to be able to complete addition and subtraction of whole numbers of at least 5 digits. However, decimals are only covered in Grade 6, and learners will therefore not be familiar with them in Grade 5. This question requires that learners understand monetary values, are able to work with decimals and can identify the correct calculation technique to solve the problem.

Error analysis

A common error was the learners selecting numbers from the question as the answer. Some learners selected the highest number (4,20 zeds) as they may not have understood what the question required. Other learners gave the price of roses (3,70 zeds) as the answer. This may have been a result of learners only recognising roses as flowers and not knowing that irises and tulips are also flowers.

Item-by-item analysis (continued)

Figure 9: Example of correct answer with working out

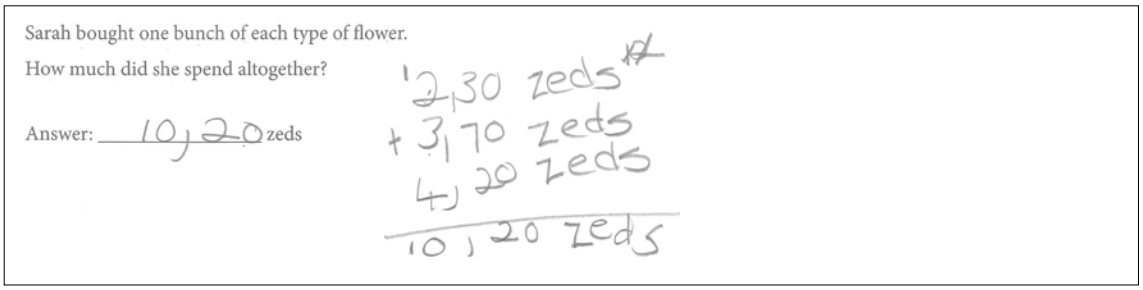
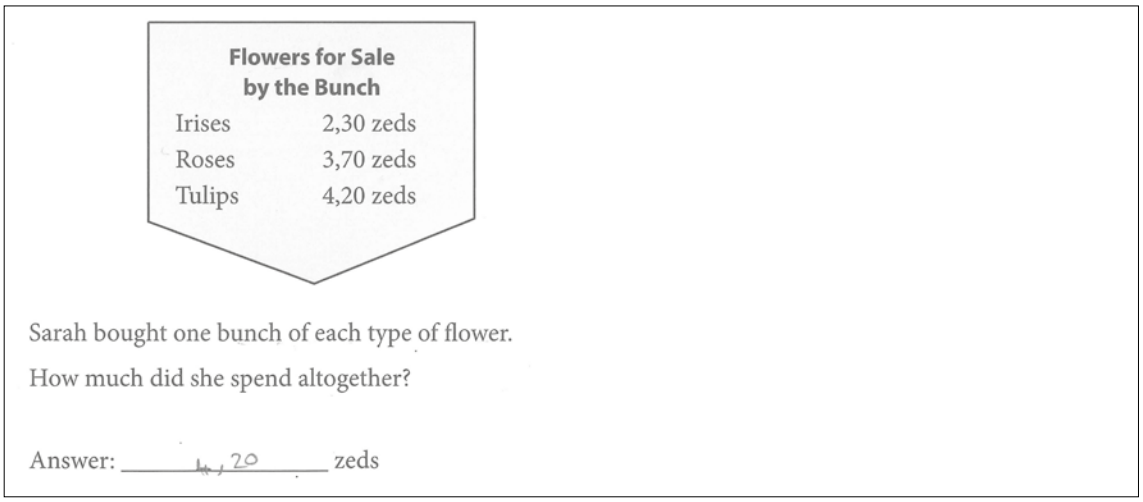
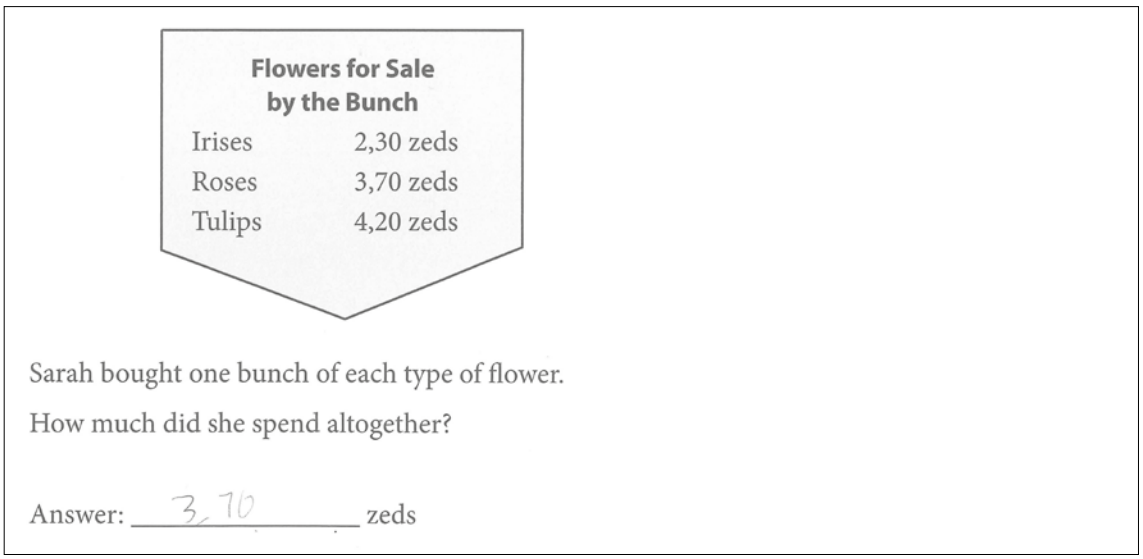


Figure 10: Examples of incorrect answers where learners chose a price from the question





Cognitive domain *TIMSS: Applying* *CAPS: Problem solving*

QUESTION 12

N04_05

Which number in place of △ makes the number sentence true?

$6 + 15 = \triangle + 10$

A. 11
B. 21
C. 25
D. 31

Learner performance

	A	B	C	D	Omitted
South Africa	**27**	43	7	21	2
International average (n=7)	**27**	38	9	21	4

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships for Grades 4 and 5. Learners are expected to be able to do mental calculations involving addition and subtraction. Learners are also taught how to solve and complete number sentences by inspection, trial and improvement, and checking the solution by substitution. Learners need to understand how to solve number sentences for this question. They must know that the expression on the left-hand side of the equation is equal to the expression on the right-hand side of the equation, and understand the use of a symbol in place of a number in a number sentence.

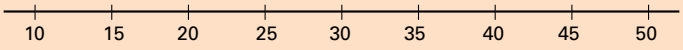
Error analysis

Of those learners who answered this question incorrectly, 43% chose option B, which was 21. This was the answer to the first half of the equation. Learners therefore were able to calculate the sum, but did not understand how to use this to complete the number sentence. Those learners who chose option C (25) may have added 15 and 10. Those who chose option D added together all of the numbers in the number sentence. The latter two common patterns suggest that when unsure, learners tend to apply what they are able to do, i.e. simple addition, rather than try to understand the more complex principle.

Cognitive domain *TIMSS: Applying* *CAPS: Complex procedure*

QUESTION 13

Thandi and Sipho are playing a game on a number line. Each move must be either to the right or to the left.



A. Thandi begins at 27 and moves 10 units. She ends on 17. Which other point could she have ended on?

Answer:_____

B. Sipho begins at 35 and moves 13 units to the left. Then, his next move is 2 units. Which point could he have ended on?

A. 22
B. 24
C. 48
D. 50

N04_08

Learner performance

Part A

	Correct	Incorrect	Omitted
South Africa	8	91	0,9
International average (n=7)	8	82	9

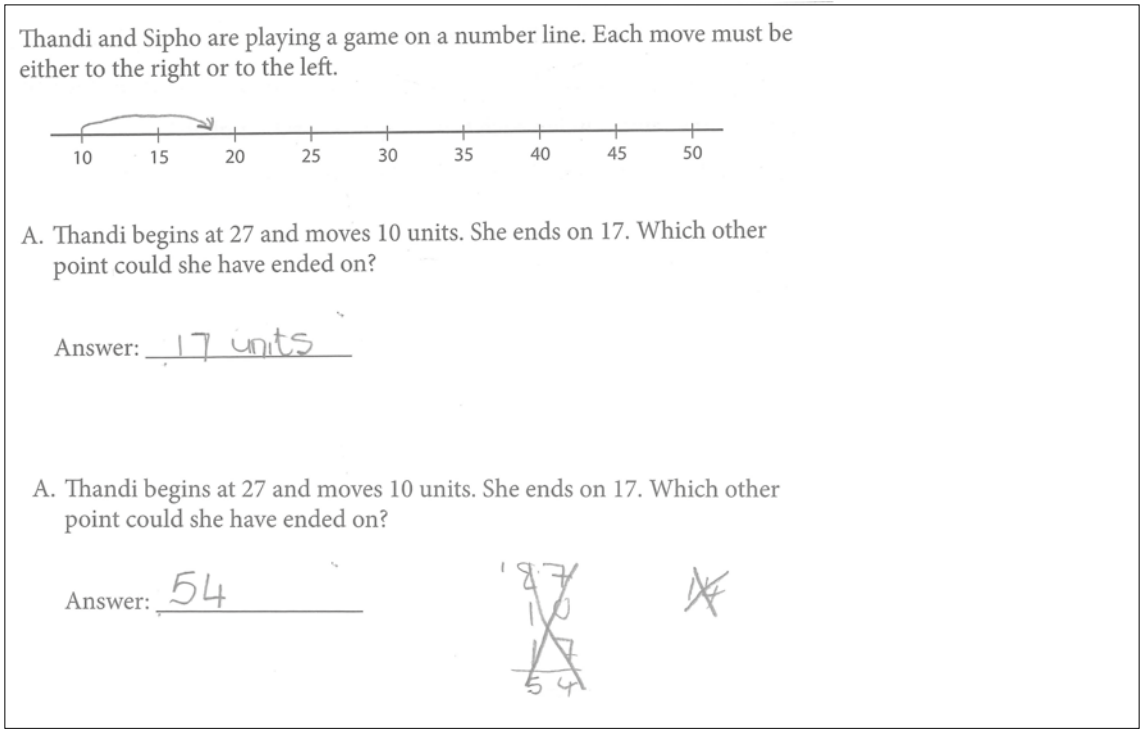
Part B

	A	B	C	D	Omitted
South Africa	21	16	27	35	0,7
International average (n=7)	24	21	25	24	4

South African curriculum

This question fits into the part of the South African Grade 4 and 5 curricula which covers numbers, operations and relationships. Learners are expected to be able to use a range of techniques to perform and check written and mental calculations of whole numbers including using a number line. An understanding of a number line is necessary for this question, and learners need to be able to locate numbers on a number line, and follow carefully the instructions given in the question. The need to answer two parts makes the question more difficult.

Figure 11: Examples of incorrect answers



Error analysis

For Part A, one of the most common errors found in this question was related to the phrasing of the question. The question asked learners which other number Thandi could have ended on besides 17. Some learners seem to have focused on the term "ended on" in the question and provided the end of the number line (50) as the correct answer. These learners therefore did not fully comprehend the question and gave the answer based on their interpretation of only a part of the question. Another common error that learners made was giving an answer of 15 or 20. These learners, rather than following the instructions of the question, looked for a number which was close to Thandi's original end point of 17. A handful of learners in the reviewed sample once again exhibited a common error which has been noted in other questions by adding up the numbers. Other learners provided one of the numbers shown in the question (7, 17, 27) as the answer, which is another error learners seem to make when they do not fully understand the question.

For Part B of the question, just over a third of learners answered incorrectly with option D, which was 50. These learners seem to have added 35 (the starting point) and 13 (the number of spaces moved), and then added 2 (the next move) which gave them 50. Therefore, instead of moving left on the number line as instructed, these learners moved right. This indicates a fundamental lack of understanding of number lines.

APPLYING

Recommendations—Numbers

Answering multi-part problems

- Learners must be taught how to read questions in their entirety and identify relevant information with which to work.
- Learners should be taught how to answer questions that have multiple parts.
- Learners must practise answering multi-part word problems that require the use of translating from word problems into mathematical terms as well as different operations.
- Learners should be exposed to different ways of answering questions related to place value.

Back to basics

- Learners struggled with the basic mathematical understanding of the relationship between the left- and right-hand sides of a number sentence. This requires consolidation of such procedures in the earlier grade, and the need for more practice examples to be utilised in teaching.
- Consolidation of number patterns is needed, with more practice examples utilised in teaching.
- Understanding of number lines must be consolidated as this principle is a foundational part of being able to manipulate and work with numerical values. More practice examples are therefore required.

Cognitive domain	*TIMSS: Reasoning*	*CAPS: Problem solving*

QUESTION 14

John made this puzzle about a 4-digit number:

The hundreds digit is 7.

The thousands digit is greater than the hundreds digit.

The ones digit is less than the hundreds digit.

What is John's number?

A. 2 708

B. 4 733

C. 8 726

D. 9 718

N04_03

Learner performance

	A	B	C	D	Omitted
South Africa	21	32	**27**	20	0,8
International average (n=7)	17	22	**42**	16	3

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships. Learners are taught to order, compare and represent numbers to at least 6-digit numbers in Grade 5. They are also taught to recognise the place value of digits in whole numbers to at least 4-digit numbers in Grade 4. Learners must have an understanding of place values in 4-digit numbers. They must also understand mathematical terms such as 'greater than' and 'less than'. The question requires the learners to read each step carefully, and consolidate these steps in order to find the correct answer.

Error analysis

This was a complex problem. The majority of incorrect answers (32%) were for option B. These learners may have read the 4 and the 7 in the question and selected the option that began with those numbers. Around 20% of learners selected incorrect options A and D, which suggests that they were able to understand and apply the first two clues given. However, they appear to have struggled with the final clue, leading them to guess or make errors (e.g. those who selected option D may have done so since it and the third clue make reference to "one").

Cognitive domain	*TIMSS: Reasoning*	*CAPS: Problem solving*

QUESTION 15

N04_04

Sally has 12 pieces of wire, 40 round beads and 48 flat beads.

She uses 1 piece of wire, 10 round beads and 8 flat beads to make 1 bracelet.

If Sally makes all her bracelets the same, how many bracelets can she make?

A. 40
B. 12
C. 5
D. 4

Learner performance

	A	B	C	D	Omitted
South Africa	42	31	12	**13**	0,8
International average (n=7)	34	32	12	**18**	4

South African curriculum

This question fits into the part of the South African curriculum which covers numbers, operations and relationships. In Grades 4 and 5 learners are taught subtraction and division of whole numbers. Knowledge of word problems is required for this question, and learners need to know how to identify what information is given and what information is required. They must also be able to identify the correct calculation techniques to use.

Error analysis

The majority of learners (42%) chose A as their answer, while almost a third of learners selected B. Those who answered A may simply have taken the 40 from the question. It is likely that those learners that answered B assumed that Sally would be able to make 12 bracelets as she had 12 pieces of wire. They did not go beyond this to calculate whether she had sufficient beads for 12 bracelets. It was necessary for learners to extend work with an unfamiliar situation which was set in a real-life context.

Cognitive domain	*TIMSS: Reasoning*	*CAPS: Routine procedure*

QUESTION 16

Siya starts to write a number pattern:

6, 13, 20, 27,……

He adds the same number each time to get the next number.

What is the next number he should write in his pattern?

Answer: _____

N04_06

Learner performance

	Correct	Incorrect	Omitted
South Africa	60	39	0,7
International average (n=7)	51	43	6

South African curriculum

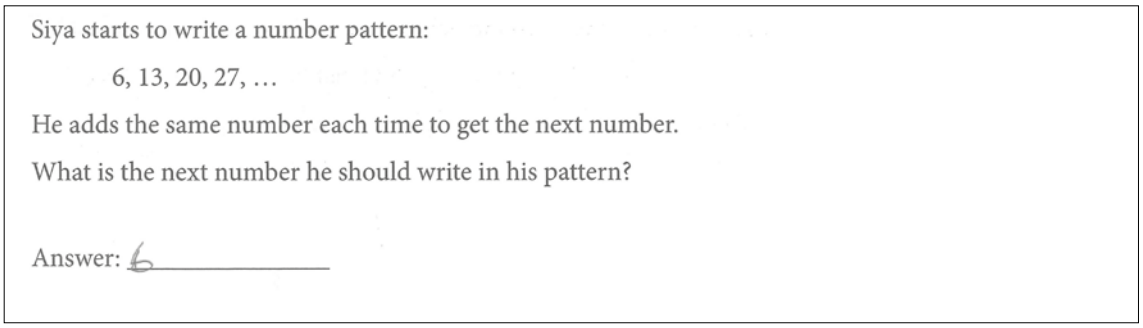
This question fits into the part of the South African curriculum which covers patterns, functions and algebra. Grade 4 and 5 learners are taught to investigate and extend numeric patterns looking for relationships or rules of patterns, including sequences not limited to a constant difference or ratio. For this question, learners must be familiar with number patterns. They must know how to calculate the number which is being added to each number in the sequence, in order to identify the next number in the sequence.

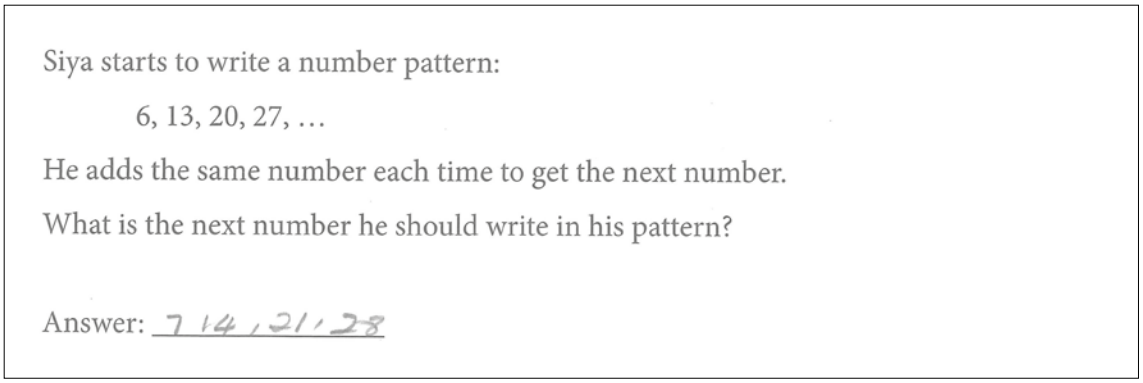
Error analysis

As 60% of learners answered this question correctly, the reviewed sample of learners contained fewer incorrect answers than for the other questions. However, some patterns emerged which may point to some areas of misunderstanding by learners. One of the errors observed involved learners repeating the last number in the number pattern in the question. They may therefore have misunderstood that they needed to go beyond what was given to them. Other learners added the first number in the sequence (6) to the last number in the sequence (27) to get the next number. These learners therefore assumed that the number pattern increased by 6 each time as this was the first number given in the pattern. Learners may have skimmed the item and misunderstood the item in general and only focused on information salient to them as the answer.

Item-by-item analysis (continued)

Figure 12: Examples of incorrect answers





REASONING

Recommendations—Numbers

Language

- Learners must be taught how to read questions in their entirety and identify relevant information with which to work.
- Learners should be taught how to answer questions that have multiple parts
- Learners should be taught how to do conversions from word problems into mathematical terms.

Problem solving strategies

- Learners must be taught to think logically and systematically.
- Learners should be exposed to different ways of answering questions related to place value, particularly where reasoning is required. Teaching strategies must therefore move assessment of "place value' from knowledge only to reasoning as well.

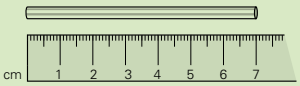
Back to basics

- Consolidation of number patterns is also needed, with the inclusion of more practice examples in teaching.

TIMSS content area: Shapes and measures

Cognitive domain	*TIMSS: Knowing*	*CAPS: Knowledge*

QUESTION 17



How long is the straw?

Answer: _____ cm

N01_09

Learner performance

	Correct	Incorrect	Omitted
South Africa	83	16	1
International average (n=7)	80	15	5

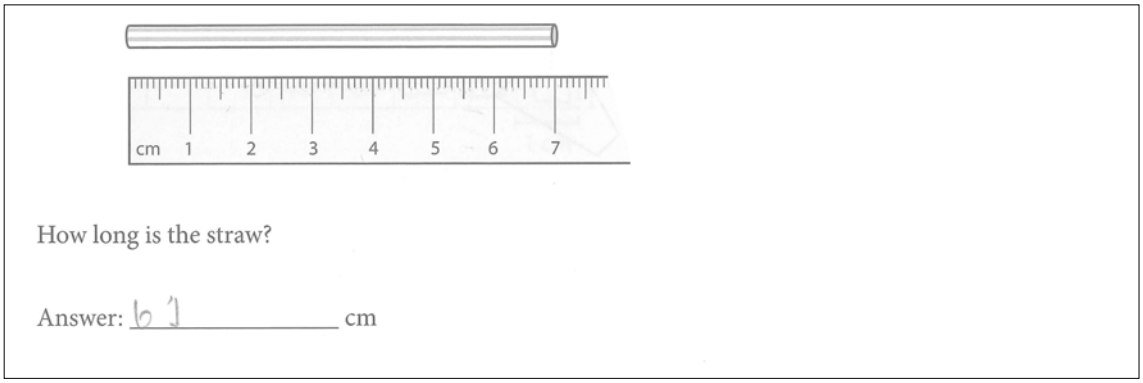
South African curriculum

This question fits into the part of the South African curriculum which covers measurement. In Grade 5, learners should be able to practically measure 2-D and 3-D objects through estimating, measuring, recording, and comparing and ordering. This area is also covered in the Grade 4 curriculum. For this question, learners must know how to read measurement correctly on a ruler. They must also be familiar with diagrammatic representations of measurement. Learners were not allowed to measure the straw using physical rulers.

Error analysis

This question received the highest number of correct responses out of the released Grade 5 items. As 83% of learners answered this question correctly (within ± 0,2 cm), the reviewed sample of learners contained fewer incorrect answers than for the other questions. However, certain patterns emerged which may point to some areas of misunderstanding by learners. Learners gave answers such as 11; 5 and 6. These learners could have misunderstood the question and given their own estimation of how long a normal straw is or they may have been unfamiliar with how to interpret figures.

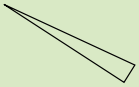
Figure 13: Example of an incorrect answer



Cognitive domain	*TIMSS: Knowing*	*CAPS: Routine procedure*

QUESTION 18

Are these shapes triangles?
Fill in **yes** or **no** for each shape.
The first one has been done for you.

		Yes	No
Is this a triangle?		●	Ⓑ
Is this a triangle?		Ⓐ	Ⓑ
Is this a triangle?		Ⓐ	Ⓑ
Is this a triangle?		Ⓐ	Ⓑ
Is this a triangle?		Ⓐ	Ⓑ

N01_10

Learner performance

	Correct	Incorrect	Omitted
South Africa	**47**	49	4
International average (n=7)	**53**	42	5

Learners had to answer correctly for all of the shapes in order for the question to be marked as correct. If they gave an incorrect answer for any of the shapes, the question was marked as incorrect. Ninety percent of learners correctly noted that the first shape (second shape in the diagram) was not a triangle and 91% answered correctly for the second shape. For the third and fourth shapes, 62% and 75% respectively correctly identified them as triangles.

Item-by-item analysis (continued)

South African curriculum

This question fits into the part of the South African curriculum which covers space and shape (geometry). This part of the curriculum teaches learners to recognise, visualise and name 2-D shapes in the environment and geometric setting, focusing on a range of shapes, including triangles. The characteristics used to distinguish, describe, sort and compare shapes are already learned by Grade 5 learners. This component of the curriculum is covered in both Grades 4 and 5. This question requires that learners are familiar with 2-D shapes, and must be able to match shapes to their names.

Error analysis

South African learners struggled with the basic mathematical identification of a triangle.

KNOWING

Recommendations—Shapes and measures

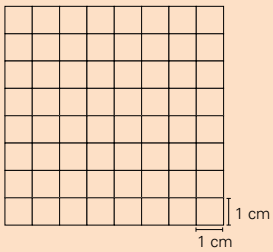
- Learners must be taught how to read questions in their entirety and identify relevant information with which to work.
- It should be ensured that graphs, figures, and diagrams are used within classroom teaching, and that learners are given practice examples.
- Consolidation of the identification of basic shapes, which should have been covered from as early as Grade R, is required. The use of more practice examples in teaching is required.

Cognitive domain | *TIMSS: Applying* | *CAPS: Routine procedure*

QUESTION 19

N01_11

Draw a rectangle that is 2 cm by 5 cm



Learner performance

	Correct	Incorrect (Wrong dimensions)	Incorrect (Other)	Omitted
South Africa	**30**	26	37	6
International average (n=7)	**41**	21	27	9

South African curriculum

Learners are taught to find areas of shapes (regular and irregular) by counting squares on grids in order to develop an understanding of square units (Measurement in the curriculum), and they are taught to draw 2-D shapes on grid paper (Space and Shape in the curriculum). To be able to answer this question learners must recognise shapes, and must be able to work out that each block in the provided diagram is equivalent to 1 cm in length. Measurement of length in centimetres is an important element of the question.

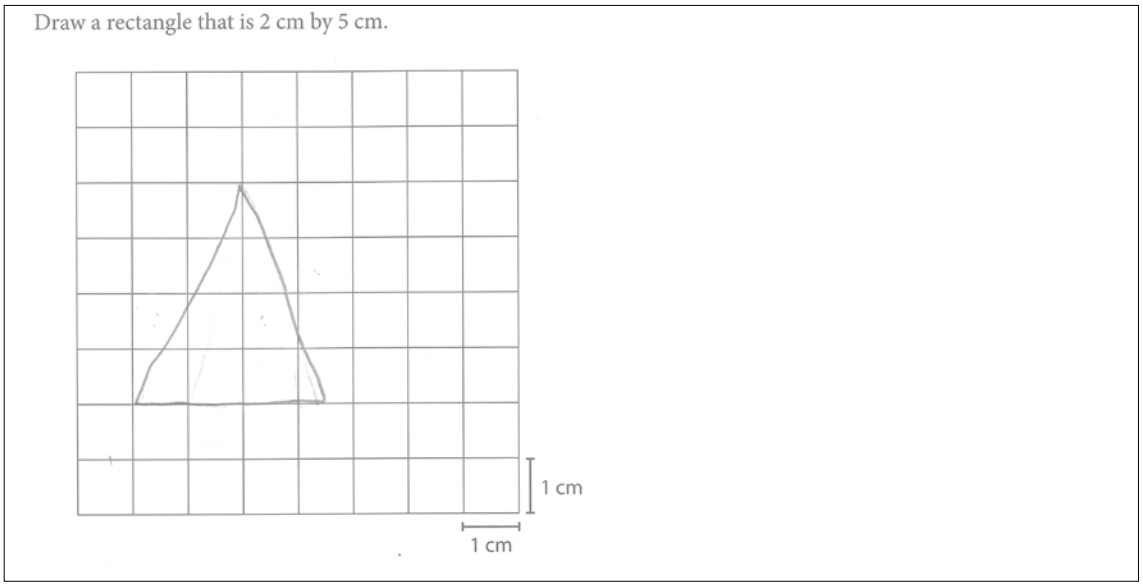
Error analysis

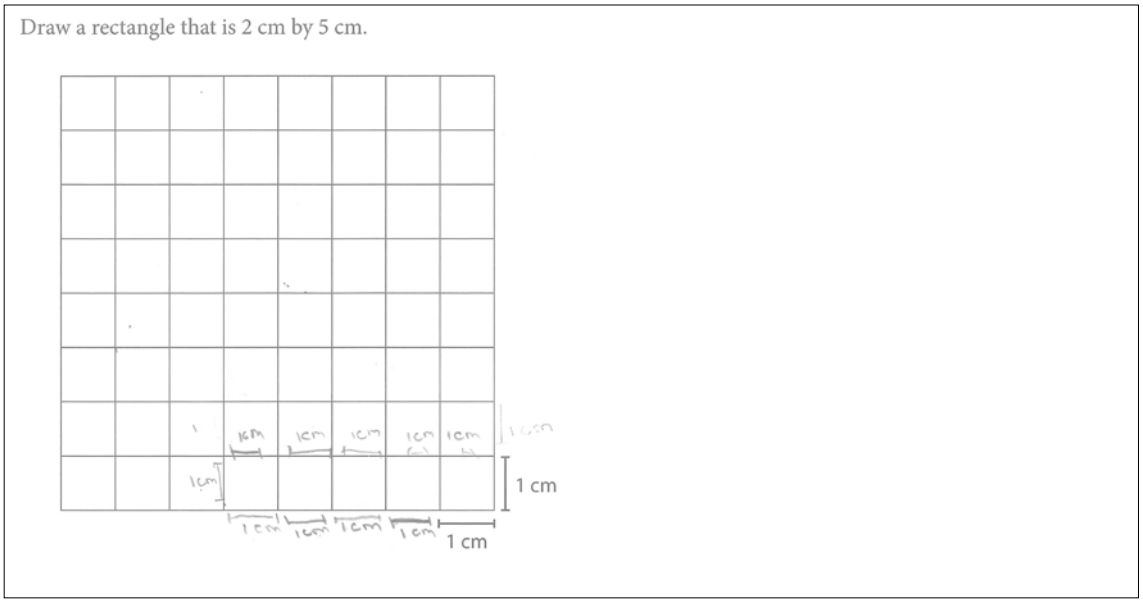
Twenty-six percent of learners drew a rectangle with dimensions other than those specified. Patterns were 1 cm by 2 cm, 1 by 5 and 2 by 4.

Another common error was the drawing of a triangle instead of a rectangle. This might have to do with the fact that the previous question dealt with triangular shapes. The learners might not have read the question properly.

Item-by-item analysis (continued)

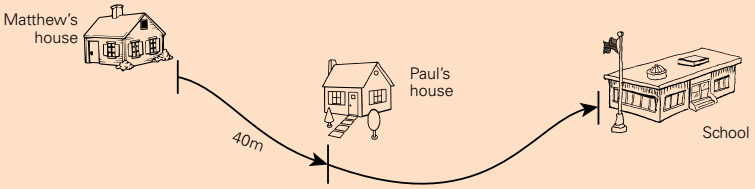
Figure 14: Examples of incorrect answers





Cognitive domain *TIMSS: Applying* *CAPS: Problem solving*

QUESTION 20



Matthew walks 40 metres on the path from his house to Paul's house. He then continues walking on the path to get to school.

How long is the path from Matthew's house to school?

A. 40 m
B. 80 m
C. 100 m
D. 130 m

N04_07

Learner performance

	A	B	C	D	Omitted
South Africa	19	51	**20**	10	0,6
International average (n=7)	17	50	**23**	7	2

South African curriculum

This question fits into the part of the South African curriculum which covers measurement. Learners are taught to do calculations and problem-solving involving length in Grades 4 and 5. This question requires an understanding of length and estimation; and in particular, estimating distance in a diagram, based on the information which is provided.

Error analysis

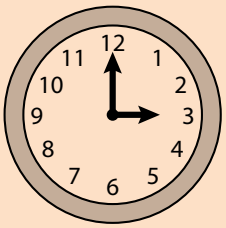
This question requires learners to estimate distance based on the given diagram. Just over half of South African learners chose option B as their answer. They therefore seem to have doubled the distance which was indicated numerically on the picture, without recognising that the distance between Paul's house and the school is longer than the distance between Paul's and Matthew's houses.

Learners also seem to have been distracted by option A (19%). This suggests that they either did not grasp what was being assessed or also took the only numerical value available as the answer.

Cognitive domain *TIMSS: Applying* *CAPS: Knowledge*

QUESTION 21

The hands of a clock at 3:00 are at a right angle. Which is another time that the hands are at a right angle?



A. 3:15
B. 3:45
C. 9:00
D. 9:45

N04_09

Learner performance

	A	B	C	D	Omitted
South Africa	54	20	**23**	2	0,6
International average	32	17	**43**	4	3

South African curriculum

This question fits into the part of the South African curriculum which covers measurement, as well as that part which focuses on space and shape (Geometry). This question required learners to be able to read time and time instruments, which is covered in the curriculum, where learners are taught to read, tell and write time in 12-hour and 24-hour formats on both analogue and digital instruments including clocks. In addition, learners needed to be able to recognise a right angle. Grade 4 and 5 learners are required to tell time. Grade 5 learners are taught to recognise and describe angles in 2-D shapes, including right angles.

Error analysis

More than half of the learners chose the incorrect answer of option A. This question involved the application of knowledge and the conceptual understanding of reading the time and recognising angles. Learners may have had difficulty integrating more than one content area and process.

APPLYING

Recommendations – Shapes and measures

Back to basics

- Identification of basic shapes should have been covered from as early as Grade R. This requires consolidation of shape identification in the earlier grades, and the inclusion of more practice examples in teaching

Consolidation

- Consolidation of drawing shapes on a grid is needed, and the inclusion of more practice examples in teaching.

Exposure

- Learners must be exposed to diagrammatic stimuli.
- Learners must be exposed to problems which require integration on more than one content area and process.
- Learners need to be taught to apply their knowledge to the familiar task of estimating a measurement within the context of a real-life situation.

Cognitive domain	*TIMSS: Reasoning*	*CAPS: Complex procedures*

QUESTION 22

The total length of the 4 sides of the rectangle is 24 metres. The length of the short side is 5 metres.

What is the length of the long side in metres?

A. 7
B. 10
C. 21
D. 29

N01_13

Learner performance

	A	B	C	D	Omitted
South Africa	**35**	34	12	17	1
International average (n=7)	**39**	26	11	18	3

South African curriculum

This question fits into the part of the South African Grade 5 curriculum which covers the properties of 2-D shapes including rectangles. Learners need to understand mathematical vocabulary related to measurement, such as "length" to answer this question. They must also be able to recognise the relevant calculation techniques to use.

Error analysis

The learners who chose option B may have added the lengths of the two short sides as this is the value given in the diagram and in the problem statement: 5+5. Those who chose option D may have added the two lengths given in the question problem statement (24+5).

REASONING

Recommendations — Shapes and measures

- Consolidation of the properties of rectangles and the measurement thereof is required, with more practice examples used in teaching.
- Currently measuring 2-D shapes is taught at the operational (knowledge) level. This must be elevated to the application and reasoning levels.

TIMSS content area: Data display

There was only one Grade 5 released item which focused on data display.

Cognitive domain *TIMSS: Reasoning* *CAPS: Problem solving*

QUESTION 23

The table below shows the sizes of large snakes.

Type of snake	Weight (kilograms)	Length (metres)
Boa Constrictor	27	4
Burmese Python	90	5 to 7
Green Anaconda	227	6 to 9
King Cobra	9	4

A. James saw a snake that was 8 metres long. Which type of snake could it be?

Answer: _____

B. Lerato saw a snake that was 6 metres long and weighed about 80 kilograms. Which type of snake could it be?

Answer: _____

N04_10

Learner performance

	Correct	Incorrect	Omitted
South Africa	**27**	72	0,9
International average (n=7)	**32**	63	5

South African curriculum

This question fits into the part of the South African curriculum which covers data handling at the Grade 4 and 5 levels. Learners are expected to be able to read critically and interpret data represented in words, pictographs, bar graphs and pie charts. They are also taught to analyse data by answering questions related to data categories, and data sources and contexts. In addition, learners should be able to summarise data verbally and in short written paragraphs that include drawing conclusions about the data and making predictions based on the data. This question requires learners to interpret and analyse the data which is given to them, and to be able to read the table correctly. Two parts to the question increase the difficulty, and Part B requires learners to consider multiple components at once.

Error analysis

Part A of this question asked learners to identify the type of snake that was 8 metres long. The most common error made by learners was to give the answer of a King Cobra, while the correct answer was a Green Anaconda. It appears that these learners looked at the weight of the snakes to answer this part of the question rather than the length, as the weight of the King Cobra was the only one close to 9.

For Part B of the question, the most common error in the reviewed sample was the answer Green Anaconda instead of Burmese Python. These learners appear to have used only the length of the snakes to determine which type of snake it was, as the data provided shows that the Green Anaconda ranges from 6 to 9 metres in length.

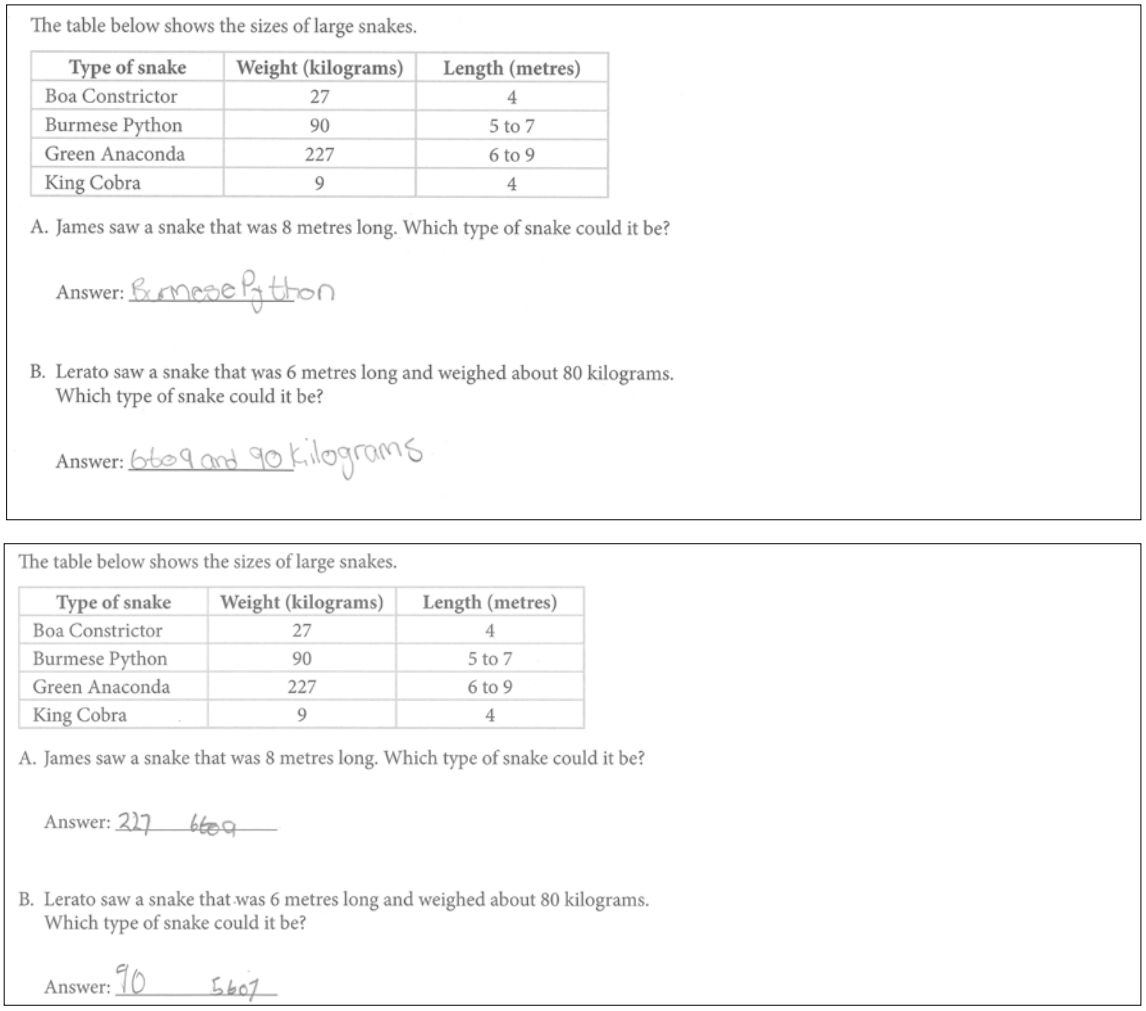
A possible explanation for these errors is that learners associated Part A of the question with the first column in the table and Part B with an answer from the second column.

Another error which was made by a large percentage of the learners in the reviewed sample was to answer one or both parts of the question using the lengths or weights of the snakes instead of their names. In many cases, the answer was still incorrect; however, in a few cases the weight or length provided matched the correct snake. Learners therefore did not understand how to interpret the table and answer the question in the correct way.

The errors made in this question point to the difficulty which these learners faced in interpreting the data provided. Learners may not be familiar with such exercises, or may not understand the need to look at all aspects of the data when answering such a question.

Item-by-item analysis (continued)

Figure 15: Examples of incorrect answers



The table below shows the sizes of large snakes.

Type of snake	Weight (kilograms)	Length (metres)
Boa Constrictor	27	4
Burmese Python	90	5 to 7
Green Anaconda	227	6 to 9
King Cobra	9	4

A. James saw a snake that was 8 metres long. Which type of snake could it be?

Answer: Burmese Python

B. Lerato saw a snake that was 6 metres long and weighed about 80 kilograms. Which type of snake could it be?

Answer: 6to9 and 90 kilograms

The table below shows the sizes of large snakes.

Type of snake	Weight (kilograms)	Length (metres)
Boa Constrictor	27	4
Burmese Python	90	5 to 7
Green Anaconda	227	6 to 9
King Cobra	9	4

A. James saw a snake that was 8 metres long. Which type of snake could it be?

Answer: 227 6to9

B. Lerato saw a snake that was 6 metres long and weighed about 80 kilograms. Which type of snake could it be?

Answer: 90 5to7

REASONING

Recommendations — Data display

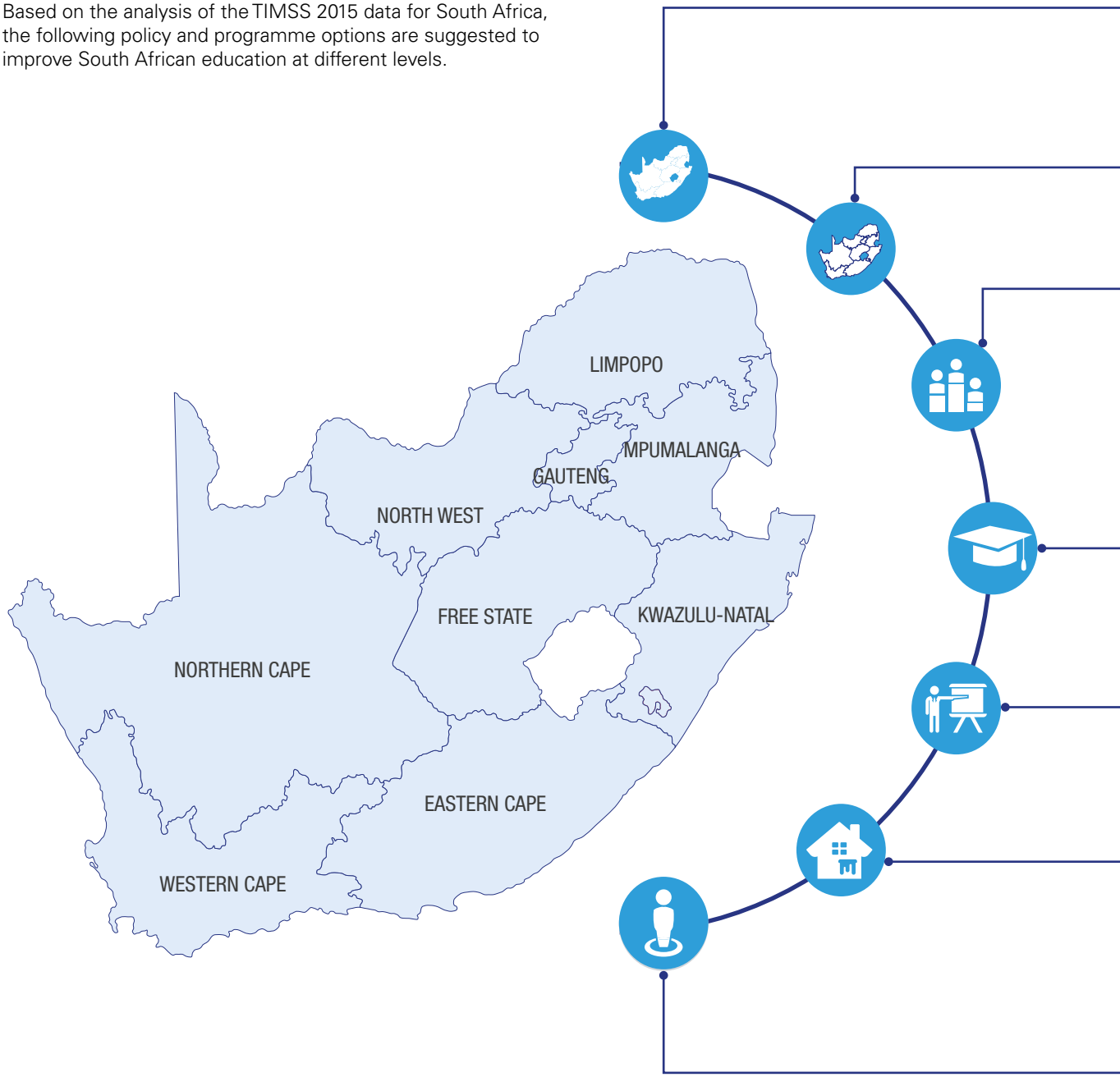
- Learners need to be given more practice examples of questions focusing on data display so -that they are able to understand and interpret data, as well as draw conclusions from this data.
- Number ranges do not form part of the Grade 5 curriculum. Learners should be exposed to ranges rather than just exact figures.

5. Conclusion

This report serves as a diagnostic indication of South African learner performance in the TIMSS 2015 Grade 5 Numeracy assessment. Several patterns of weakness and suggested remedial actions were identified and it is hoped that this will be beneficial for all role-players and stakeholders in the South African education system. This includes curriculum and assessment specialists in DBE, other curriculum managers, and especially educators in their day-to-day classroom teaching practice. It is hoped that this will guide systemic improvement in a holistic way to ensure quality education for all South African learners.

How do we improve the chances of success for South African learners?

Based on the analysis of the TIMSS 2015 data for South Africa, the following policy and programme options are suggested to improve South African education at different levels.



National level

It is important for the national government to:

- Ensure that the delivery of mathematics and science courses in all schools is in line with curriculum requirements
- Work towards an improvement in performance in national and international assessments based on realistic targets
- Embark on a differentiated strategy of interventions and support for improving learning outcomes in fee-paying and no-fee schools
- Improve the provision of pedagogical infrastructure and resources to schools
- Use public media to create awareness and set up programmes in mathematics and science
- Revisit the repetition policy and its implementation
- Generate awareness of the full range of career possibilities that learners can pursue beyond Grade 9
- Develop policies and guidelines to curb school violence and bullying

Provincial level

It is important for each provincial department of education to:

- Increase the percentage of learners achieving above the minimum competency level of 400 points
- Monitor the provision and use of pedagogical resources in schools
- Emphasise a high quality of teaching and learning from Grade R
- Implement policies and guidelines to curb school violence and bullying

District level

It is important for district education officials to:

- Design appropriate pedagogical interventions for teachers
- Monitor that teachers and learners are in school, on time and teaching/learning
- Monitor that textbooks, workbooks and pedagogical resources are in schools and being used
- Investigate teacher job satisfaction and motivation
- Monitor incidences of violence and bullying at schools, and support the management of school safety

Schools

It is important for school management teams to:

- Emphasise safety, order and academic success
- Monitor and manage rates of absenteeism among teachers and learners
- Emphasise an academic culture in schools
- Provide appropriate support to grade repeaters, either during school time or during school holidays
- Implement policies and guidelines to curb school violence and bullying

Teachers

It is important for teachers to:

- Ensure that they arrive at school on time to start teaching
- Evaluate their own professional knowledge and pedagogical practices, and improve on these
- Provide learners with practice examples involving written explanations

Communities and households

It is important for community members and families to:

- Motivate young children to see the importance of education
- Motivate and inspire young children to value mathematics and science
- Monitor teacher and learner attendance at schools
- Support and monitor homework and school reports
- Engage with teachers and school officials about education delivery and performance

Learners

It is important for learners to:

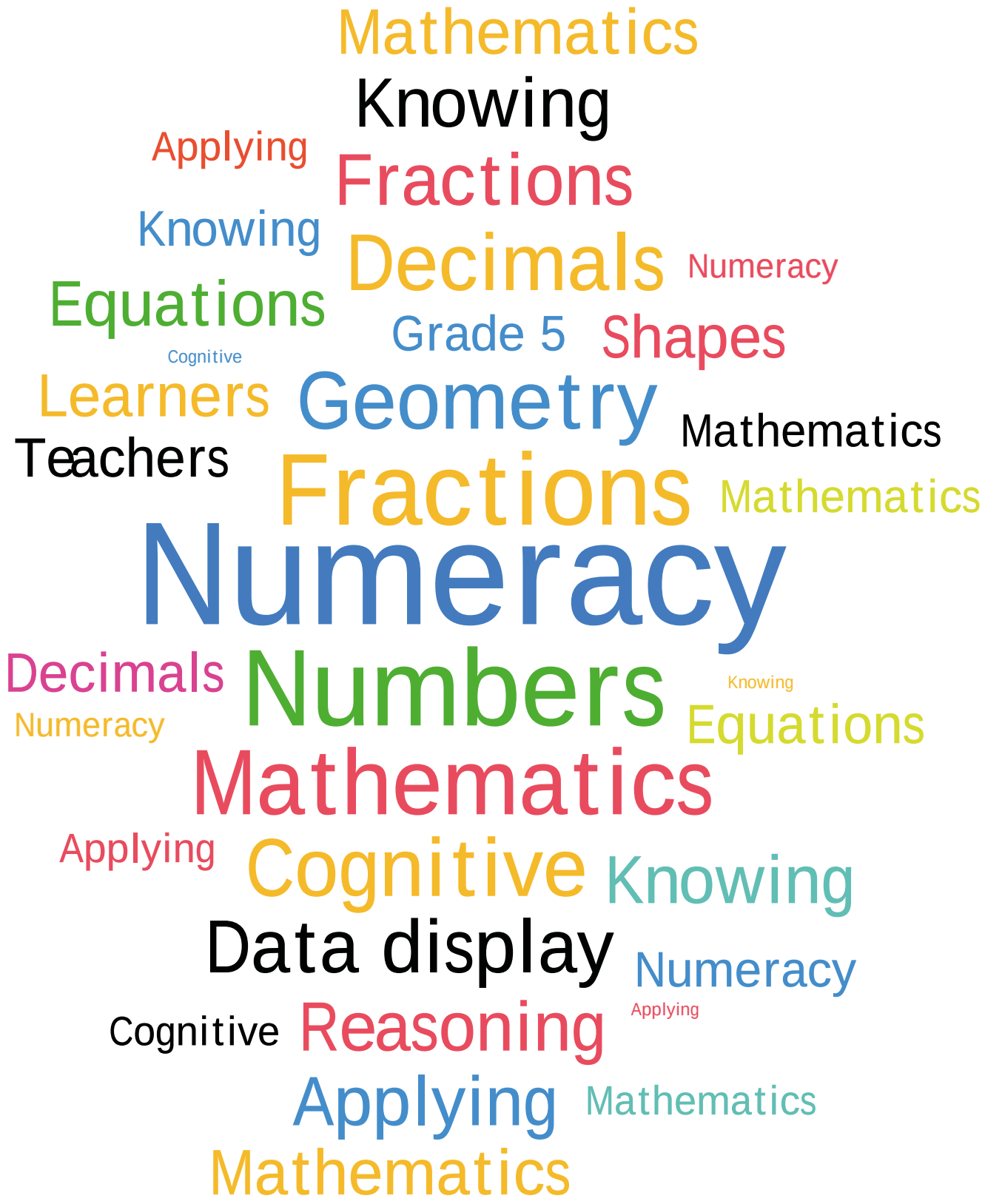
- Arrive at school, and to their classes, on time
- Improve their proficiency in the test language
- Ensure regular practice of mathematics and science examples with written homework

References

Mullis, I.V.S. & Martin, M.O. (Eds.). (2013). TIMSS 2015 Assessment Frameworks.
Retrieved from http://timssandpirls.bc.edu/timss2015/frameworks.html

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016).
TIMSS 2015 International Results in Mathematics.
Retrieved from http://timssandpirls.bc.edu/timss2015/international-results/

Reddy, V., Isdale, K., Juan, A., Visser, M., Winnaar, L., and Arends, F. 2016.
TIMSS 2015: Highlights of Mathematics achievement of Grade 5 South African Learners.
Human Sciences Research Council.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Applying
Fractions
Knowing
Decimals
Numeracy
Equations
Grade 5
Shapes
Cognitive
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Mathematics
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