Investigating the content of mathematics textbook used in 8th grade in Malaysia based on content domain of TIMSS.

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Abstract

The purpose of this study is to investigate the content of Mathematics Textbook in Secondary schools 8th grade (Form 2) in Malaysia, based on content domain of TIMSS .The reason of this study is to indicate that although the average score of students were usually more than International average score, it is lower than South East Asian Countries like Japan, Singapore, south Korea Hong Cong chains Tape. We identified two main reasons for this lack of performance among Malaysian students. First, we revealed that, as compared to the base content of TIMSS, mathematic textbook (Form 2) has some lack of richness. We also revealed that the change of teaching language from Bahasa Malaya to English may have affected the students' achievement in Mathematics.

Key words: Content domain, TIMSS, Numbers, Algebra, Geometry, Data & Chance, Malaysian students, Mathematics, Educational mathematics.

1. Introduction

Mathematics education has always been treated as an important section of general education and specifically science education. Mathematics became the driving force for almost all technological and scientific developments in the 19th and 20th century. It also had large impact on all activities in the professional, social and daily life (Maasz & Schloeglmann, 2006). Technology and science have a significant function in realizing the aspiration of Malaysia in order for becoming a developed nation. Mathematics is influential in the growth of technological and scientific knowledge, therefore, providing outstanding mathematics education starting from an early age is essential (Curriculum Development Centre Malaysia, 2006). In order to evaluate students' performance and to develop policies to improve their achievements in science and mathematics at different levels of education, it is suggested to compare their knowledge and competencies in the area with the students of the other countries. One such evaluation is conducted by Trends in International Mathematics and Science Study (TIMSS) that evaluate students in 4th, 8th, and advanced grades (before university) in every four years among voluntary countries in the world.

The review of TIMSS report, particularly for the eighth-grade level, reveals that south-eastern Asian countries, including Japan, China, South Korea, Hong Kong and Singapore have obtained almost the best ranking in mathematic content domain and cognitive domain which is mentioned in TIMSS 1999, 2003, 2007 and 2011. Although Malaysia has gotten ranking around more than international average as shown in Table 1, its ranking is usually lower than neighboring countries such as Singapore.

Table 1. TIMSS ranking in 8th Grade based for some Southeast Asia countries (Mullis et al. (2004, 2008 and 2012)).

Country	Score of participants				Ranking of participants			
	1999	*2003*	*2007*	*2011*	*1999*	*2003*	*2007*	*2011*
Japan	579	570	570	570	5	5	5	5
South Korea	587	589	597	613	2	2	2	1
Chines Taipei	585	585	598	609	3	4	1	3
Singapore	604	605	593	611	1	1	3	2
Hong Kong	582	586	572	586	4	3	4	4
Malaysia	519	508	474	440	16	10	20	26
International average	487	466	500	467	-	-	-	-

Given the fact that content of textbooks is indeed a key factor which can influence the achievement of students in mathematics (Rezat, 2006), there is a need to find the reasons for such a gap among the mathematics scores obtained by Malaysian students in TIMSS and students' scores in other south-eastern countries.

2. Students' Achievement in Mathematics Content Domains of TIMSS

TIMSS mathematics assessment for mathematics items in eighth grade includes four content domains of Numbers, Algebra, Geometry, and Data and Chance (Statistics and Probability). Indeed, comparing the students' achievement in different contents will better explain mathematics achievement for each country. For achieving this aim, it is necessary to compare and analyze the content of the mathematics textbooks (Form 2) in Malaysia with content domains of TIMSS. Consistently, Table 2 compares the Malaysian students' achievements in different content domains (in TIMSS). As expected, Table 2 reveals that also the average scale score of eighth grade Malaysian students' achievement was around the international average in TIMSS, however, Malaysian students' performance in TIMSS has not been higher than leading south East Asian countries that hold the highest ranking in TIMSS such as Singapore. More importantly, Figure 1 and Table 2 signify that the ranking of Malaysian students' achievements in TIMSS in all content domains has decreased in 2007, and 2011 as compared to 2003.

We have indeed identified two key issues that can possibly explain the unsatisfying and continually decreasing mathematical achievement of Malaysian students. One part of the above-mentioned problem might be related to the education policy in changing the language of instruction of Mathematics and Sciences from Malay into English. As Tan and Saw Lan (2011) highlighted that in non-urban area schools in Malaysia teachers have not been able to teach fully in English in Mathematics and Science classes. Consistently, we performed a series of interviews with teachers and attended to some mathematic classes in Peninsular Malaysia to understand whether teaching in English hinders mathematic achievement among Malaysian students.
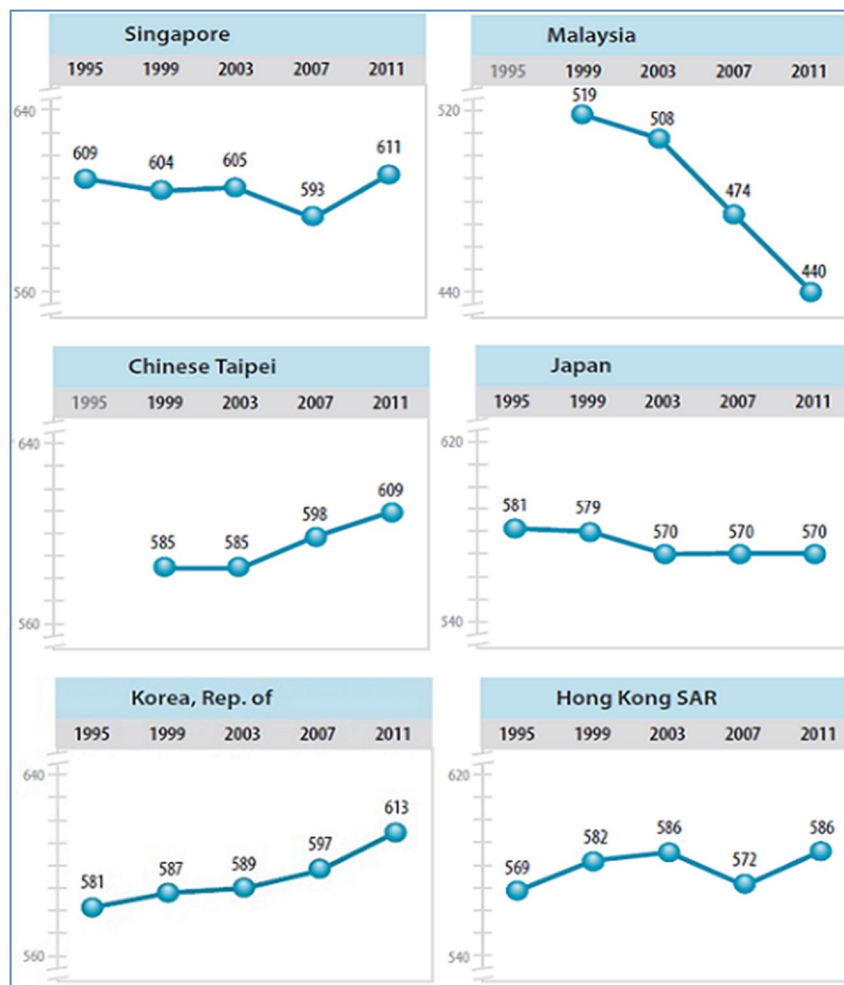
Figure 1. Trends in Mathematics Average Achievement in TIMSS 1995 to 2011 (Mullis et al. (2012), pp. 60-64).

More importantly, the disadvantaged position of Malaysian students in terms of mathematic achievement in different domains might be due to the content of mathematic textbooks in Malaysia. Therefore, we investigated the content of the Malaysian mathematics textbook (Form 2) based on the common contents in TIMSS.

Table 2. Malaysian Students' Achievements in Content Domains in TIMSS 2003, 2007, and 2011

TIMSS content domains	TIMSS 2003					TIMSS 2007				TIMSS 2011		
	AVS*	Ranking	INA	HIT	VAS	Ranking	INA	HIT	AVS	Ranking	INA	HIT
Number	524	9th	467	618	491	17th	500	597	451	23rd	N/A	618
Algebra	495	17th	467	597	454	27th	500	617	430	29th	N/A	617
Geometry	495	14th	467	598	477	19th	500	592	432	26th	N/A	612
Data & Chance	505	17th	467	579	469	19th	500	580	429	24th	N/A	616

* Note: There is no average achievement in 2011 based on its report (TIMSS 2011, p. 144). Average scale Score, AVS, International average; INA, HIT; Highest score. N/A; not available.

3. Research Method

For this study, as a qualitative research and case study, the researcher investigated the content domains of Malaysian mathematics textbook (Form 2) based on the content domains of TIMSS including Number, Algebra, Geometry, and Data & Chance based on documents of Ministry of Education in Malaysia (MOE) Mathematics textbook in 8th & 7th

grades and reports of TIMSS. Since some of the questions in TIMSS are not limited to eighth grade textbooks and deal with the content of textbook in seventh grade (Form 1), therefore, the researcher has also studied on seventh grade (Form 1). Although the data were mainly gathered via document analysis, we partially used the insight of Malaysian 8th Grade teachers of mathematics because we visited some schools and performed some interviews and observations as a part of our qualitative study.

4. Results

4.1 Mathematics Textbook Content in Malaysia

In general, mathematics education in Malaysia secondary schools includes five years starting from Form 1 to Form 5 (7th grade to 11th grade). Students in Form 1, 2, and 3 study a general syllabus including a package of two books and a CD for Form 1, a package of two books and a CD for Form 2, and a package of one book and a CD for Form 3. In Form 4 and 5 all the students study a general mathematics textbook (Form 4 & Form 5), and those who want to choose science and engineering fields in the university, need to take additional mathematics in 10th and 11th grades. The title of all books as printed on the first page of the books is; "Integrated Curriculum for Secondary Schools; Curriculum specifications Mathematics" approved by the MOE and Curriculum Development Center (2006).

The aim of this study is to investigate Malaysian students' achievement in mathematics in eighth grade (Form 2) which will be compared to the mathematic achievement in domains as reported in TIMSS. We explained that part of the above-mentioned problem might be related to the Education policy in changing the language of instruction of Mathematics and Sciences from Malay into English. We explained that content of textbooks can significantly impact mathematic achievement; therefore, we evaluated the content domains of Malaysian mathematics textbook (Form 2) based on the content domains of TIMSS including Number, Algebra, Geometry, and Data & Chance. Since some of the questions in TIMSS are not limited to eighth grade textbooks and deal with the content of textbook in seventh grade (Form 1), therefore, the researcher has also studied on seventh grade (Form 1).

In general overview, Form 2 mathematics syllabuses contain 13 chapters in two volumes. In volume one, there are seven chapters including: (1) direct numbers; (2) squares, square rotes, cubes, and cube rotes; (3) algebraic equations II; (4) linear Equation; 5) rations, rates and proportions; (6) Pythagoras' Theorem; (7) geometrical constructions. In volume two, there are six chapters including (8) coordinates; (9) loci in two dimensions; (10) Circles; (11) transformations; (12) solid geometry II; and (12) statistics.

Form 1 mathematics syllabuses contain 12 chapters in two volumes. Volume one has three chapters including; (1) whole numbers; (2) number patterns and sequences; and (3) Fractions. Volume two has nine chapters including consequently: (4) decimals; (5) Percentages; (6) integers; (7) algebraic expressions; (8) basic measurements (9) lines and angles (10); polygons (11); perimeter and area; and (12) solid geometry. Both volumes come with a complimentary CD.

Each chapter ends with a summing up section including a chart summarizing all the concepts introduced in the chapter and a checklist for students to evaluate their achieved ability. There is also a section named 'Enrichment Activity' which has questions regarding the subject of each lesson. For solving these questions, sometimes, students can use computer and CD. The lesson ends with summative exercises, skill review and covering all the concepts introduced in the chapter.

The Content of textbooks Form (1 & 2) in Malaysia is explained based on content domains of TIMSS as below:

(i)   Numbers: In eighth grade (Form 2), 50 pages in two chapters are devoted to Numbers including Directed Numbers, Squares, Squares Roots, Cubes, and Cubes Roots. In seventh grade (Form 1) 162 pages in seven chapters are devoted to Numbers including Whole Numbers, Number Patterns and Sequences, Fractions, Decimals, Percentages, relationship among them, and Integers. In total, there are 212 pages in two Forms.

(ii)   Algebra: In Form 2, four chapters with 82 pages are devoted to Algebra topics including, Algebraic expressions 2, linear equations Ratios, Rates, Proportions, and Coordinates. Form 1 includes one chapter with 12 pages devoted to Algebraic expressions 1. In total, 94 pages are devoted to Algebra in Form 1 and Form 2.

(iii)   Geometry: In Form 2, seven chapters with 128 pages are devoted to geometry topics involving Pythagoras' Theorem, Geometrical Constructions, and Loci in two Dimensions, Circles, Transformations, and Solid Geometry. In

Form 1, three chapters with 67 pages are devoted to geometry topics including Lines &Angles, Polygons, Perimeter & Area, and Solid Geometry. In total, 195 pages are devoted to geometry topics in Form 1 and 2.

(iv)   Data & chance: In Form 2, only one chapter is devoted to Data (Statistics) and there is not any topic in relation to chance (probability) in this book. One chapter with 31 pages is devoted to Data (Statistics) topic including Concept of data, Concept of frequency, and Representation and Interpretation of Data. It should be added that neither Data nor Chance are discussed in Form 1.

The researcher summarized the above findings in Table 3 These findings included the pages devoted to each topic in Form 1 and 2 and their percentages in comparison with the items in TIMSS 2007 and 2011.

Table 3. Investigating the content of Form 1 & 2 in Malaysia based on content domains of TIMSS.

Content Domain of mathematics textbooks in Malaysia	Form 1 Grade 7		Form 2 Grade 8		Form 1 & 2		TIMSS items 2007 & 2011
	pages	%	pages	%	pages	%	
Numbers	162	67	50	17	212	40	30%
Algebra	12	5	82	28	94	17	30%
Geometry	67	28	128	44	195	37	20%
Data and Chance (Statistic and Probability)	0	0	31	11	31	6	20%
Total	241	100	291	100	532	100	100%

Note: In TIMSS 2003, the content domain devoted to Number is 30%, Algebra 24%, Measurement 16%, Geometry 16%, and Data & Chance 14%.

In Malaysia eighth grade "Form 2", 50 pages are devoted to Numbers (17%), 82 pages to Algebra (28%), 128 pages to Geometry (44%), 31 pages to data (11%). It is important to note that chance is not taught in eighth grade. In seventh grade "Form 1", 162 pages are devoted to Numbers (67%), 12 pages to Algebra (5%), 67 pages to Geometry (28%), and there is no lesson related to data and chance. In Malaysia, in seventh and eighth grades, the total number of 212 pages (40%) is devoted to numbers, 94 pages (17%) to algebra, 195 pages (37%) to geometry, 31 pages (6%) to data, and no pages (0%) to chance.

5 .Discussion of Finding

5.1 Number
We found that Malaysian students have had the best performance in the Number content domain as compared to other content domains. From Table 2 it is clear that Number content domain has outperformed other domains in all the three TIMSS reports of 2003, 2007 and 2011. We believe the main reason behind the good performance of Malaysian students in Number content domain is indeed the rich content of mathematics textbooks in this area, compared to other areas. In other words, Form 1 and Form 2 have a variety of exercise and examples regarding Numbers, and hence, students get a mastery over this issue. This fact is indeed evident in Table 3. Despite the advantage over other domains, Malaysian students have a sever achievement disadvantage in the Number content domain compared to other south-eastern Asian counties such as Japan, Singapore and Hong Kong. The item depicted in Figure 2 may better explain why Malaysia has a significantly less achievement in the Number content domain.

In the example depicted in Figure 2 the purpose is to show the result of multiplying two fractions between zero and one which leads to this point that the result of multiple would be less than each fraction. For solving the item in Figure 2, we offer the following inequality, the one that exists in countries with leading achievement in Number content domain, but missing in Malaysian students' mathematic textbook. Thus, the lack of examples to support each main topic in the Number content domain has indeed caused Malaysian students to obtain only 18% correct achievement for the item in Figure 2, which Hong Kong for example has obtained the 18% correct
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If $0 < \frac{a}{b} < 1$ & $0 < \frac{c}{d} < 1$ *and* $\frac{a}{b} \times \frac{c}{d} = N$ $\rightarrow$ $N < \frac{a}{b}$ & $N < \frac{c}{d}$
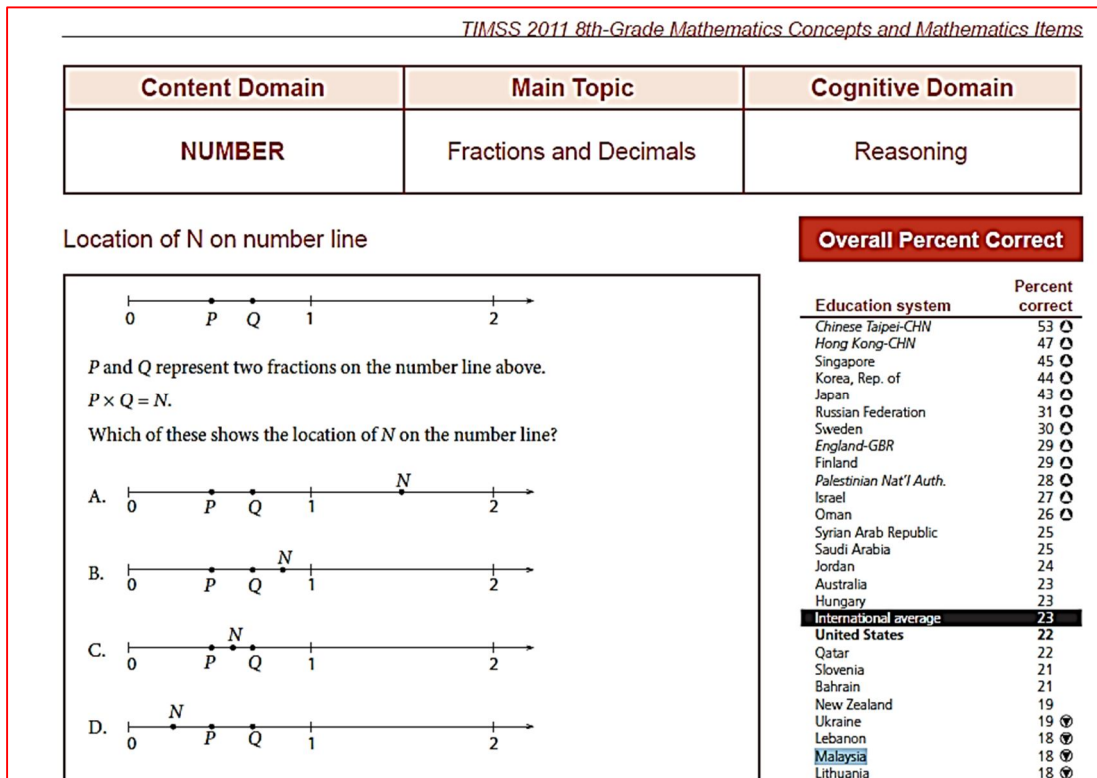
Figure 2. Inequality example used in Number content domain in TIMSS 2011 (p. 7).

We however observed that when Malaysian students have perceived a particular exercise, their performance is interestingly close to other leading south-eastern Asian counties. Figure 3 provide a clear example of this fact. In the exercise depicted in Figure 3 Malaysian students obtained 91% correct indicating that their ranking comes after Singapore having the highest ranking. In effect, Malaysian students performed well in this example because similar examples had been provided to them in Form 1, as exemplified in Figure 4.
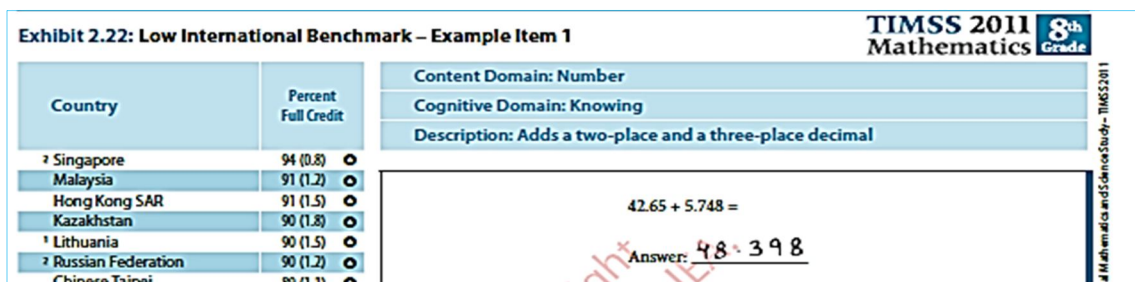
Figure 3. The decimal example used in Number content domain in TIMSS 2011 (p. 122).
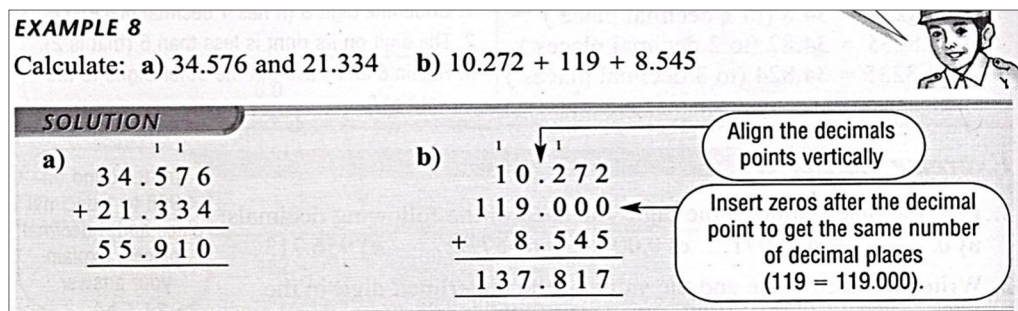
Figure 4. The decimal example used in Form 1, Volume 2 (p. 8).

5.2 Algebra

According to Table 3, in TIMSS, 30% of the items are devoted to Algebra items, however, in Malaysian textbooks in Form 1, 5% and in Form 2, 28% (total 17%) have been devoted to Algebra. This might be the reason for Malaysian students' achieving average scale score in TIMSS (2003, 2007, and 2011) which is around the international average score. Also, based on TIMSS (2003, 2007, and 2011) the ranking of Malaysia was 17th, 27th, and 29th respectively. In Form 1 only one chapter is devoted to Algebra on Algebraic Expressions including concept of unknowns, Algebraic terms and expressions. In Form 2 volume 1 three chapters are devoted to Algebra including ratio, rate and proportion and algebraic expression in two or more unknowns.

We observed that Malaysia did not perform well in items related to linear equations with two unknowns. As shown in Figure 5, Malaysia ranked under the average (30th) in the linear equation item. The reason is that in Form 1 and 2, these equalities have not been mentioned. Also, Malaysia was similarly under-ranked in 'Algebraic Expression' (Figure 6) as compared to the international average because the similar examples and exercises had not been provided in Form 1 and 2.
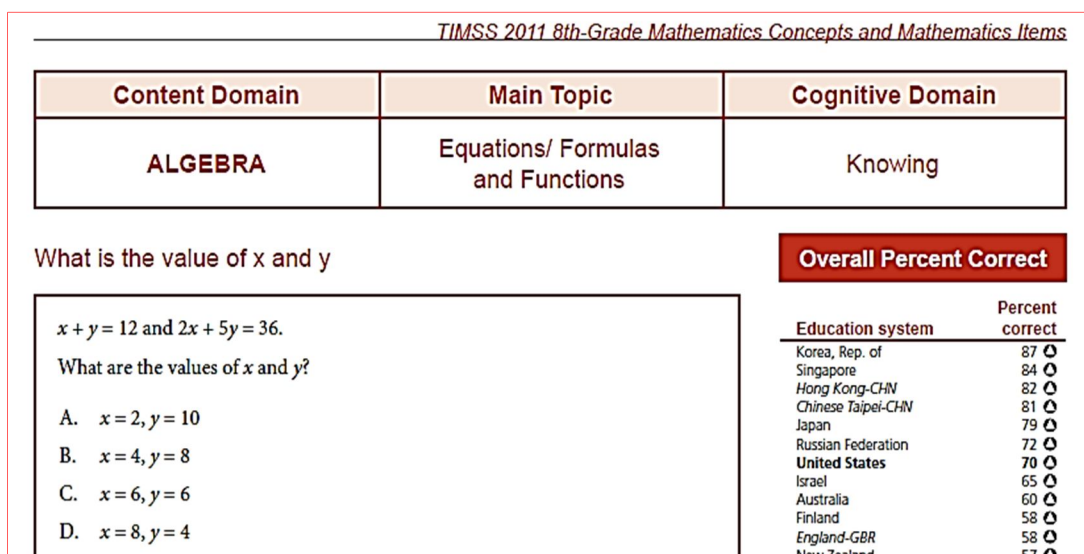
Figure 5. Released mathematics items of TIMSS 2011 (p. 61).
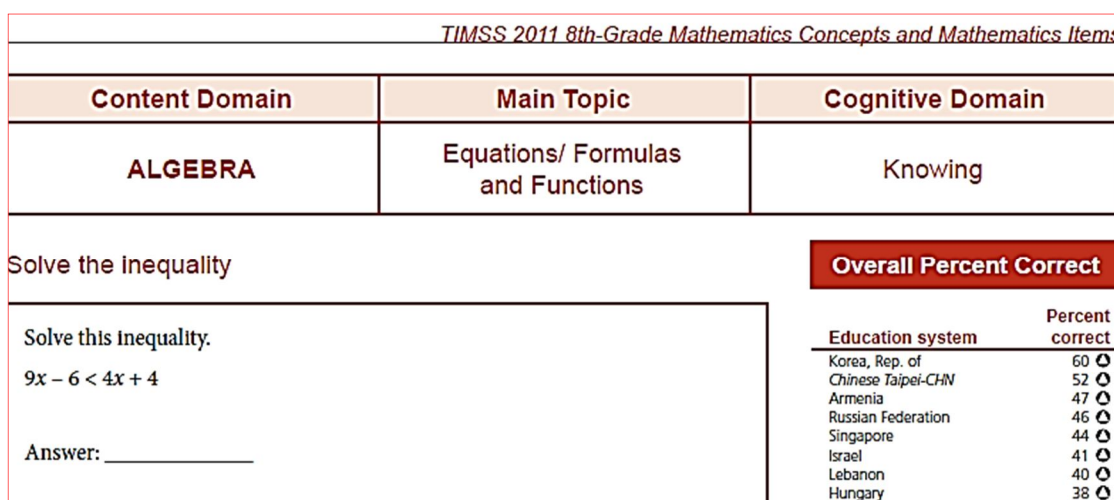
Figure 6. Released mathematics items of TIMSS 2011 (p. 49).

Alternatively, Form 1 and Form 2 contain few topics about patterns. Looking at Malaysian students' performance in TIMSS 2003, 2007, and 2011 shows that they are able to solve simple pattern items. As shown in Figure 7 and 8,

Malaysia ranking in pattern topic has been near the international average. The reason behind their fairly well performance in patterns despite the insufficient materials in their textbooks can be that Form 2 includes two sections called 'discovery activity' and 'enrichment activity' which improve Reasoning abilities of the students. Also, in Form 1 at the end of each section there is a part called 'mathematics around us' that is related to problem solving. This part as well as the enrichment sections help to enhance students' Reasoning abilities.
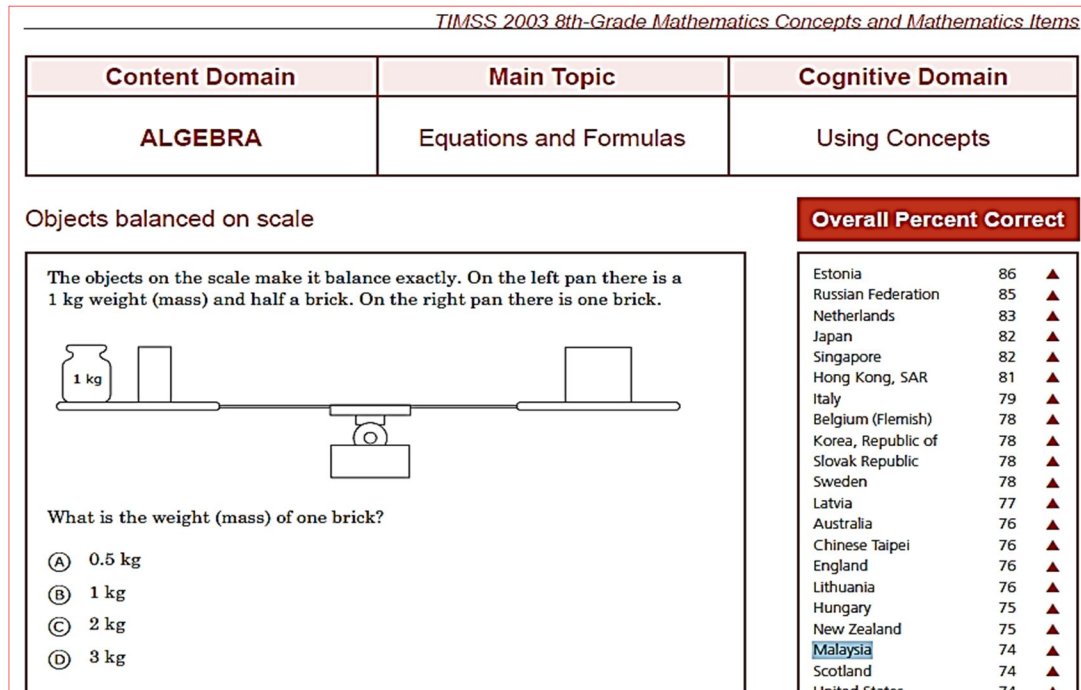
Figure 7. Released mathematics items of TIMSS 2011 (p. 20).

In particular and for the exercise in Figure 7 we offer following equality as the answer.

$1+ \frac{X}{2} = X \rightarrow 1 = X - \frac{X}{2} \rightarrow 1 = \frac{2X-X}{2} \rightarrow 1 = \frac{X}{2} \rightarrow X = 2$
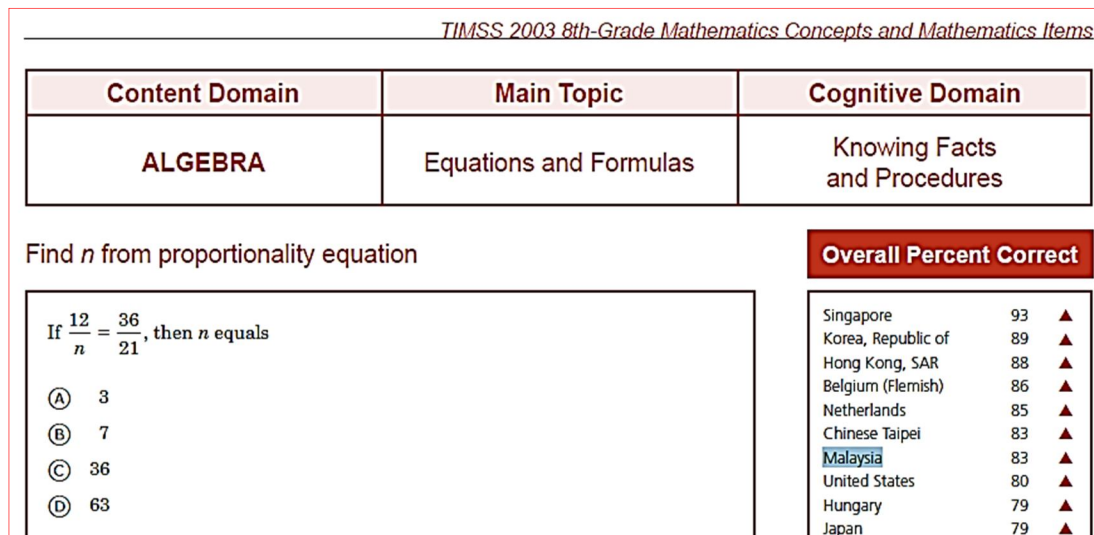
Figure 8. Released mathematics items of TIMSS 2011 (p. 11).

We observed that in Form 2 there are sufficient explanations and examples on this 'linear equation' topic resulting in high ranking of Malaysia TIMSS 2003.

5.3 Geometry

In Malaysian textbooks, in Form 1, 28% and in Form 2, 44% is devoted to topic of Geometry (totally 37% in Form 1 & Form 2) and in TIMSS, 20% of items are devoted to Geometry. Therefore, it is expected that Malaysia achieved rather high scale score in TIMSS. While, ranking of Malaysia in TIMSS 2003, 2007, and 2011 are 14th, 19th, and 26th, and the average of scale score of Malaysia has been around the international average. Accordingly, finding and evaluating the reasons for rather low performance of Malaysian students have been necessary.
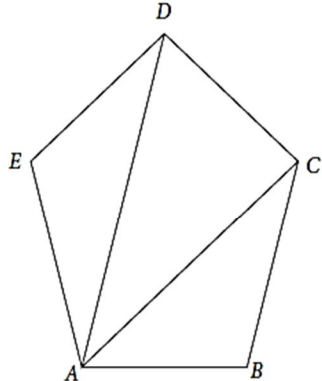
The following item (Figure 9) in TIMSS 2011 is related to pentagon topic. Malaysian students' performance was 6% which was considerably lower than average, while Japan for example performed extremely well (72%). The reason might be related to this issue that Form 1 and 2 did not discuss about pentagons. Regular pentagon is an attractive and important topic in Geometry, yet Malaysian textbooks did not include this topic.

Figure 9. The pentagon example in TIMSS 2011, (p. 76)

As a matter of fact, the TIMSS results showed that for those items which were similar to the examples in Form 1 and 2, the Malaysian students often performed better. The TIMSS item illustrated in the Figure 10 is one example of this kind. Malaysia ranked as 12th in this Geometry item. As shown in Figure 11, Form 1 contains examples of this kind, and hence, Malaysian students were already familiar with the concept.
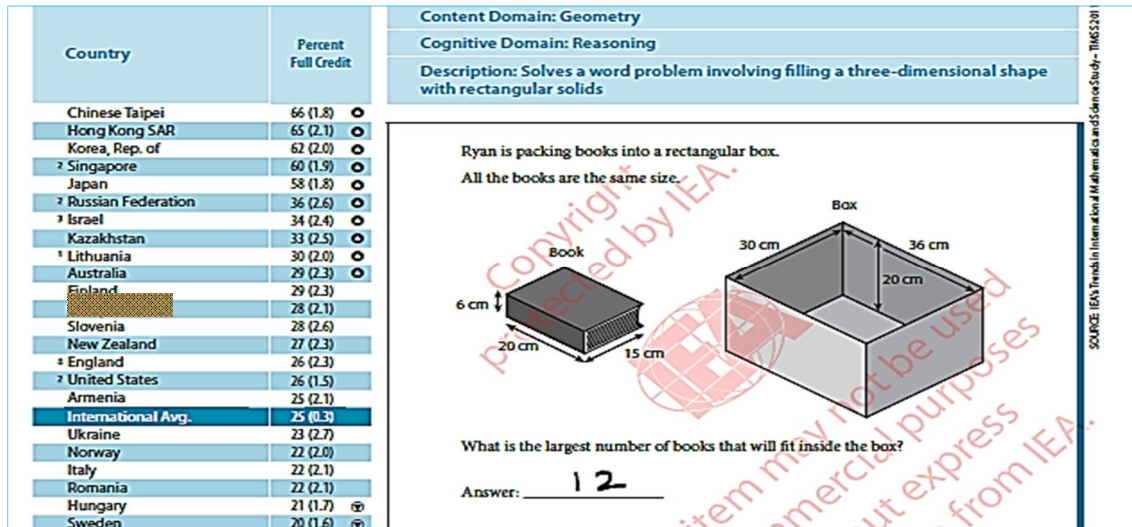
Figure 10. Released mathematics items of TIMSS 2011 (p. 136).
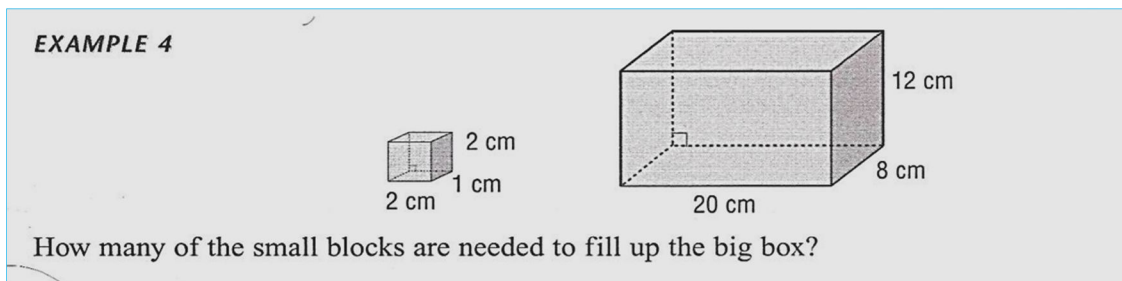
Figure 11. The Geometry example used in Form 1, Volume 2 (p. 155).

5.4 Data & Chance (Statistics & Probability)

Data and Chance topic were not taught in seventh grade (Form 1) in Malaysia. Malaysian students learned these concepts in eighth grade (Form 2) for the first time. The number of pages devoted to Data is only 31 (6%) pages and the concept of Chance (Probability) was not covered. Moreover, the subjects covered in the textbook were limited. But the performance of Malaysian students in this content domain in TIMSS 2003, 2007, 2011 has been relatively good. The ranking of Malaysia in TIMSS 2003, 2007, 2011 has been 17th, 19th, 24th respectively.

Concerning the Figures 12, the main topic of Chance (probability) in TIMSS 2011 has been included in the items, whereas these items have not been mentioned in Form 2 and therefore, this might be considered as a reason for the score of the Malaysian students that was lower than international average score (25%).

Figure 12. Released mathematics items of TIMSS 2011 (p. 92).

Malaysian Mathematics textbooks (Form 1 and Form 2) also did not include any particular Data content domain such as chance, mean, median. But students' rankings in TIMSS 2003 were more than international average. In particular and as depicted in Figure 13, Malaysian students performed exceptionally well in the Data content domain of TIMSS 2003. While visiting different schools in Malaysia, and observing teachers' teaching behavior, we noticed that Malaysian teachers tent to discuss and explain about some topics of Data content domain such as mean. This may indeed explain the satisfying performance of Malaysian students in the Data content domain as shown in Figure 13.

Figure 13. Released mathematics items of TIMSS 2011 (p. 4).

6. Conclusion

In this study we tried to understand why Malaysia has a lower ranking in mathematic content domain and cognitive domain in TIMSS (1999, 2003, 2007 and 2011) as compared to leading south-eastern Asian countries, including Japan, China, South Korea, Hong Kong and Singapore. Our research identified two key reasons for this issue.

Firstly, the above-mentioned problem might be related to the education policy in changing the language of instruction of Mathematics and Sciences from Malay into English. We should note that the language teaching in Malaysia schools was changed from Bahasa Malay to English since 2003. A quick look at Figure 1 shows that Malaysia raking in TIMSS started to get lower since 2003. In our interview with mathematic teachers in Malaysia, and direct observations of different schools we noted that some teachers are still not comfortable teaching Mathematic in English and some part of students' lacks some English skills to fully comprehend Mathematic materials in English. Our finding provides support

81

for the recent study of Tan and Saw Lan (2011) who demonstrated that in some Malaysian schools, particularly in non-urban area, teachers have not been able to teach fully in English in Mathematics and Science classes.

Secondly, we demonstrated that as compared to the base content of TIMSS, mathematic textbooks in Malaysia, particularly Form 2, have some lack of richness. In our content analysis we noted that in Malaysia's textbook, after presenting a subject, in some chapters, the number of given examples were quite less than the presented exercises. It should be noted that the ranking of reasoning and knowing skills in Malaysian students is higher than their ranking of applying based on TIMSS. The reasons for this issue could be explained in such a way that firstly, the number of given examples in each lesson is often less than the number of presented exercises and therefore, the examples do not cover all the issues offered in the exercises. Secondly, in each chapter there are some problem solving examples (living with mathematics) and discovery learning examples which all emphasize the enhancement of students' reasoning and knowing skills. For example, the students often obtain an acceptable score in some TIMSS items such as data and chance, while those items have not been presented comprehensively before in their textbooks. It may be due to good students' reasoning and knowing skills. For instance, in Data content domain, Mean, Medium, and Mode have not been presented in the section on Data, but students' ranking was quite higher than the international average score in TIMSS, that might be because teachers have done extra work in the classes.

The other reason that Malaysian students have not been enabled to achieve high rankings in TIMSS is lack of some of the subjects in the mathematics books (Form 1 & 2). For example in Algebra the subject of linear equations with two unknown variables and also the subject of inequality have not been presented in Form 1 & 2. However, the questions regarding these subjects have been presented in TIMSS.

Another issue which is noted in this part is the matter of visualization. In researcher's opinion, the visual characteristics of the Malaysian textbook (Form 1& 2) were weak and boring. Most of the content was mono-colored (black & white) and the graphs, charts, tables, and pictures were not very attractive for students. There was no separating space between different sections or examples, therefore the content of the text almost on each page seemed to be very unattractive.

6.1 Implications

The ultimate aim of this study is improving Malaysian students' achievements in mathematics in general and improving their ranking in TIMSS in particular. Considering this general aim and the objectives of this study; the results obtained from this research may be useful for Curriculum development center, Ministry of Education Malaysia. The comparison of achievements in TIMSS, between Malaysia and other countries may be used by this center to give a more clear insight about the situation in Malaysia and how to improve it.

The results may also be used by curriculum designers and text book writers. The thorough analysis textbooks from Malaysia (from 2) based on TIMSS content criteria can provide textbook writers and curriculum designers with a deeper insight and ideas to improve the curriculum to facilitate higher achievements in mathematics learning. The other two groups which may benefit from this study are mathematics teachers and students. They can use the findings both directly, through applying and using some of the results and the methods provided; and indirectly, through using the improved curriculum and textbooks. This may lead in higher mathematics proficiency and higher rankings in TIMSS.

6.2 Limitation and Future Research Directions

The present study has some limitations that readers should take into consideration while interoperating the findings. First and foremost, we only relied on the content analysis of mathematics textbooks in Malaysia and the comparison with TIMSS standards. There we did not capture the perceptions of experts from MOE in Malaysia regarding the possible reasons of Malaysian students' lower achievement in TIMSS domain contents. Secondly, we evaluated the content appropriateness of mathematics textbooks in Malaysia merely based on TIMSS standards while we cannot ensure that having high achievement in TIMSS content domains literally means the high performance of students in Mathematics. Thus, future research can complement our findings with evaluating the mathematic performance of Malaysian students from perspectives other than TIMSS.

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