Effects of Malaysian Secondary Schools Mathematics Teachers' Familiarity with TIMSS on Students' Achievement in Mathematics

Abdolreza Lessani [1], Aida Suraya Md Yunus [1], Rohani Ahmad Tarmiz [1] & Rosnaini Mahmud [1]

[1] Faculty of Educational Studies, Univesiti Putra Malaysia, Serdang, 43400, Serdang, Selangor, Malaysia. Re.lessani@yahoo.com

Abstract

Many nations nowadays take international comparisons of students' achievements to assess their success in education. In the mathematics context, Trends in International Mathematics and Science Study (TIMSS) is a well-recognized intentional comparative study that is being carried out to offer insight into students' achievement and to evaluate a country's own mathematics education system and practice. The review of TIMSS report, particularly for the eighth-grade level in 2003, 2007 and 2011 shows that although Malaysia has gotten ranking around more than international average in the mathematics achievement, however, its ranking has usually been lower than leading South-East Asian countries such as Hong Kong, Singapore and Japan. The present study proposes that the lack familiarity with the TIMSS content domains including Number, Algebra Geometry, and Data & chance (Statistics & Probability) among Malaysian secondary school mathematics teachers can be an important reason for such a lack of mathematics achievement in Malaysia. We conducted several interviews with the teachers to address this issue and concluded that when the familiarity of a teacher with TIMSS increases, he/she may introduces mathematics concepts to students, from the TIMSS content domains, which do not exist in the Malaysian mathematics textbooks content.

Key words: Content domain, TIMSS, Malaysian students, Malaysian secondary schools, Mathematics achievements, IEA.

1. Introduction

In the 1960s, the International Association for the Evaluation of Education Achievement (IEA), which is an independent international organization of national research institutions and government agencies that has been conducting studies of cross-national achievement in a wide range of subjects since 1959, conducted the First International Mathematics Study (FIMS) which tested mathematics achievement of 13 year-old students in the final year of secondary schools in 12 countries (Ross & Genevois, 2006). In the 1980s, IEA undertook SIMS which tested mathematics achievement of 13 years old students in the final year of secondary schools among 20 countries. In 1995, IEA undertook the Third International Mathematics and science study known as TIMSS, tested over a half-million students in 50 countries. The target population of TIMSS were 9-year olds (grade 3-4), 13-year olds (grade 7-8), and the students in the final year of secondary school. Since 1995 this study has conducted on a regular 4-year period and it has been named TIMSS. In 1999, TIMSS has been conducted among 38 countries in the 8th grade I which Singapore ranked first while Malaysia, as we country of interest in this study, ranked sixteen (Ross & Genevois, 2006).

TIMSS consists of an assessment of mathematics and science, as well as student, teacher, and school questionnaires. In 1995, the evaluation involved level 4, 8, and the high school final year. To be enabled to evaluate the students' knowledge, assessment features show a series of complexity and difficulty. The pupil questionnaires are planned to gather information on the backgrounds, beliefs and approaches of students, connected to learning and schooling, information concerning their classroom experiences, amongst lots of other subjects. The teacher and school questionnaires enquires regarding mathematics and science content coverage, class scheduling, teachers' educational backgrounds and preparation, school policies, amongst numerous other subjects.

TIMSS was established by a widespread partnership amongst participating countries. Measurement, Curriculum, and education specialists from throughout the world worked jointly to generate the evaluation structures, questionnaires, and item pools. TIMSS is structured on the schools curricula around the world, and is planned to consider in which ways pupils are offered educational chances, and the issues which affect how pupils using these chances. Having its foundation in the schools curricula throughout the world, TIMSS aims to examine three levels: the implemented curriculum; the intended curriculum; and the achieved curriculum. The intended curriculum is described as the science and mathematics which societies aim for pupils to learn and in what ways education systems are prepared to obtain this order; the implemented curriculum could be explained as what is really trained in classrooms, who educates it, and in what ways it is educated; the achieved curriculum is what pupils have learned. The different questionnaires search for information on the implemented and intended curriculum; the evaluation searches for ascertaining what pupils recognize. TIMSS provide valuable information about students' science and mathematics achievement in an international area.

Mathematics education has always been considered as an important component of general education and specifically science education. 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 relevant to compare their knowledge and competencies in a specific area with students of the other countries. One such evaluation is conducted by Trends in International Mathematics and Science Study (TIMSS). TIMSS as an international comparative study has attracted an influential audience in many countries. This comparative study is being carried out to offer insight into students' achievement that will support reflection on a country's own system and practice. TIMSS in effect establishes reliable and valid scores for achievement that can be compared across countries or across groups of students within countries, and relates achievement to various background and context variables. Consistently, TIMSS has given educational stakeholders a lot of information that may be helpful in their planning for better education (Eklöf et al., 2014).

In arguing TIMSS's reports, Patterson et al. (2003) stated that the function of mathematics has altered because a worldwide necessity for mathematics efficiency has grown considerably in the modern countries. In addition, Furner et al. (2005, p. 16) reported that it becomes "more and more important that all citizens be confident in their ability to do mathematics" to become productive members of society. In addition, the NCTM (2000, p. 50) reported, "in this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures. Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed."

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 has usually been lower than neighboring countries such as Singapore.

According to research and writings in mathematics education, there are many factors for a teacher to be successful in teaching including teachers' beliefs, knowledge of mathematics, having knowledge about teaching methods, how to write lesson plans, and being familiar with different institutes such as IEA that conducts the periodic TIMSS. We have consistently identified a key issue that can possibly explain the unsatisfying and continually decreasing mathematical achievement of Malaysian students. In this study we investigated the extent to which the familiarity of Malaysian mathematics teachers with TIMSS has affected the Malaysian students' achievement in mathematics.

Table 1. TIMSS ranking in 8th Grade based for some Southeast Asia countries (Mullis et al. (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	-	-	-	-

2. Malaysia's achievement in 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 the 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.

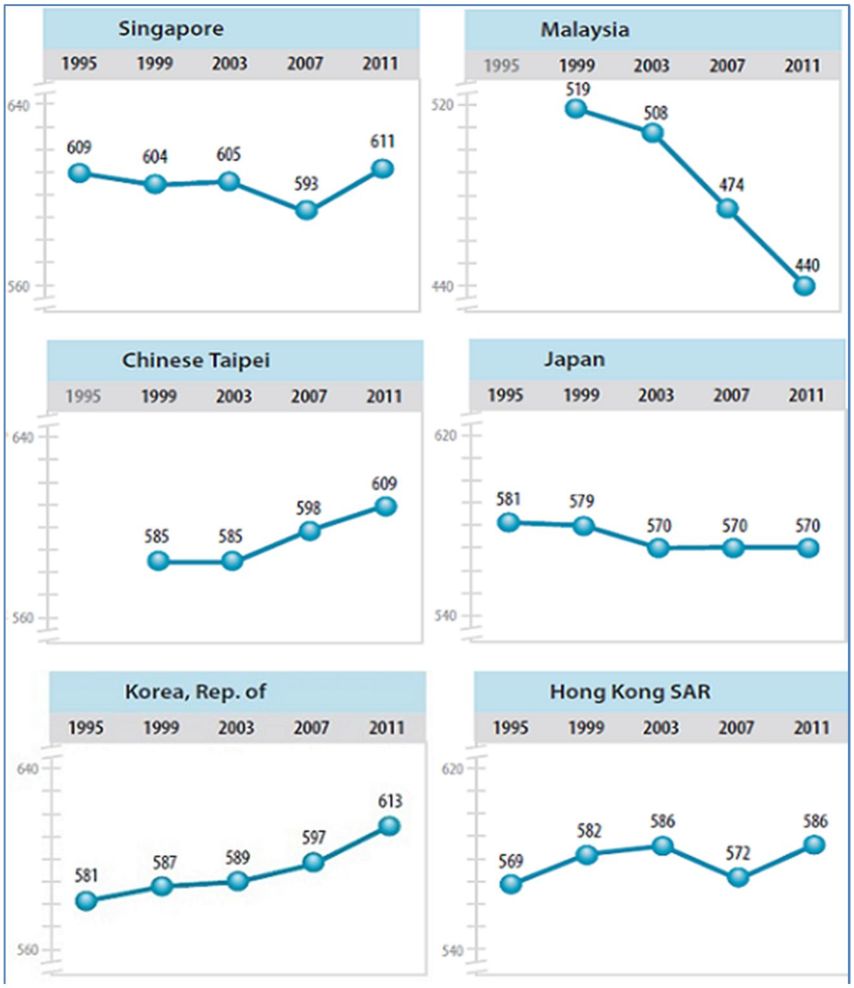


Figure 1. Trends in Mathematics Average Achievement in TIMSS 1995 to 2011 (Mullis et al. (2012), pp. 60-64).

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

To achieve objectives of this study, the current research used a qualitative research method for collecting and analyzing the data. The qualitative method used in this study is a kind of case study using interview and observation as the techniques for data collection. In this study we interviewed seven mathematics teachers (Teachers A to G). The participants were selected through a snowball sampling method from two secondary schools located in Serdang and Putrajaya, Malaysia. Snowball sampling is a procedure for developing a research sample where existing study participants take on future participants from amongst their acquaintances. Therefore, like a rolling snowball, the sample size grows throughout the process of the research. As the sample is constructed, enough data is assembled to be helpful for research (Doherty, 1994; Heckathorn, 1997; Seale et al. 2004; Castillo, 2009). Our decision for selecting respondent from Selangor state was made under the assumption that the Selangor teachers' understanding of the TIMSS did not differ from teachers in other states of Malaysia since they were trained in higher education institutions that uphold the same standards.

4. Discussion and conclusion

In our interviews with the teachers, and observations of their classes, we found that the teacher A was familiar with TIMSS but was not familiar with the content domains of TIMSS. We also found that only teacher G was partially familiar with the content domains of TIMSS, although Malaysia has been attending TIMSS since 1999. The other teachers were not familiar with the content domains of TIMSS. They did not also have proper knowledge about the content of textbook of other countries such as Singapore and South Korea, which are higher ranking holders in the content domains of TIMSS. We interestingly observed a considerable difference in the teaching practice of the teacher G who was relatively familiar with content domains of TIMSS. We indeed observed that she, occasionally, provided her students with examples that did not exist in their mathematics textbooks 8th grade (Figure 3) but these example had quite similarly been presented in TIMSS' items (refer to Figure 2 & 3). An example that she wrote on the whiteboard was linear equation with two variables $\frac{X}{Y} = \frac{7}{2}$ and X + Y =63, with answers X = 7 and Y = 2. And with the result X + Y = 9 which was an interesting problem for discussion. Teacher G asked the students to solve the posed problem as below:

$\frac{X}{Y} = \frac{7}{2}$ and X+ Y = 63

If $\frac{X}{Y} = \frac{7}{2}$ and we know that (7, 2) =1, so we can say X=7 and Y=2 which was the students answer in the mathematics class room, then X + Y = 9. But in this case there is another function X + Y = 63, so we cannot say X=7 and Y = 2 because X +7 doses not equal to 63, so we have to solve the problem as two equations with two unknowns because we want to find the solution of the equation as following:

$$\frac{X}{Y} = \frac{7}{2} \rightarrow 2X = 7Y \rightarrow 2X - 7Y = 0$$

$$X + Y = 63 \rightarrow Y = 63 - X \; (2) \rightarrow 2X - 7(63 - X) = 0 \rightarrow 2X - 441 + 7X = 0$$

$$9X = 441 \rightarrow X = \frac{441}{9} = 49 \rightarrow Y = 63 - 49 \rightarrow Y = 14$$

Then the true answer is:

X=49 and Y=14→ X + Y= 63

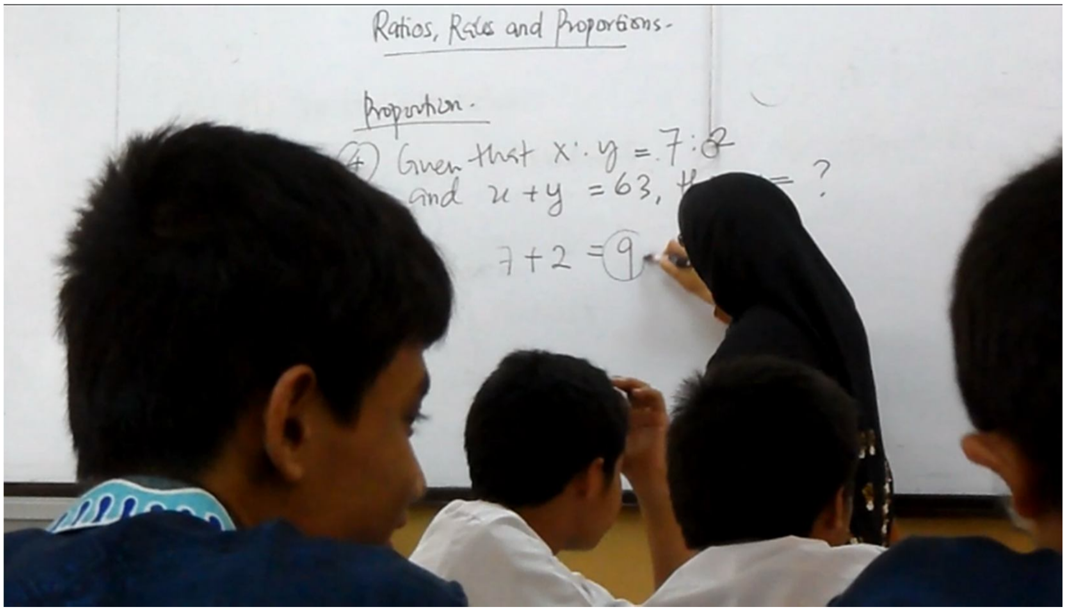
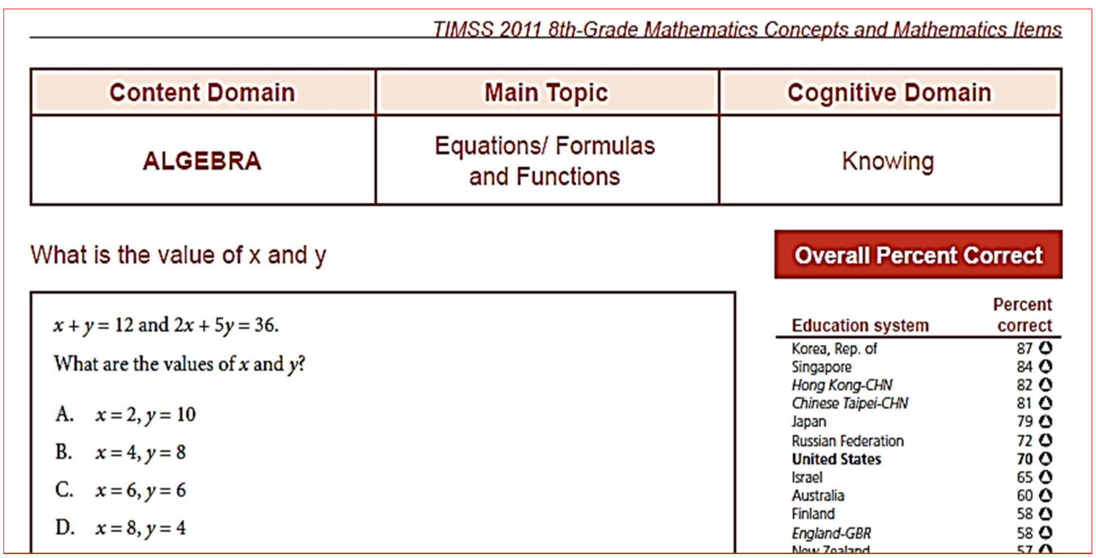


Figure 2. Teacher G reaching Form 2 in the 8th crade class.



TIMSS 2011 8th-Grade Mathematics Concepts and Mathematics Items

Content Domain	Main Topic	Cognitive Domain
ALGEBRA	Equations/ Formulas and Functions	Knowing

What is the value of x and y

$x + y = 12$ and $2x + 5y = 36$.

What are the values of x and y?

A. $x = 2, y = 10$

B. $x = 4, y = 8$

C. $x = 6, y = 6$

D. $x = 8, y = 4$

Overall Percent Correct

Education system	Percent correct
Korea, Rep. of	87
Singapore	84
Hong Kong-CHN	82
Chinese Taipei-CHN	81
Japan	79
Russian Federation	72
United States	**70**
Israel	65
Australia	60
Finland	58
England-GBR	58

Figure 3. Algebra item with two unknowns, TIMSS 2011, p. 61.

We consistently conclude that teachers' familiarity with the content domains of TIMSS can have a significant impact on the mathematics achievement of students. It is therefore concluded that the lack of familiarity of Malaysian secondary school mathematics teacher might be a key reason for the unsatisfying performance of Malaysian 8th grade mathematics students, in various content domains of TIMSS, as compared to leading South-Asian countries such as Japan and Singapore. Therefore, one operative approach for the Malaysian government and relative agencies, such as Ministry of Education and Curriculum Development Centre is to launch programs and campaigns in an effort to increase the familiarity of Malaysian secondary school mathematics teacher with various content domains of TIMSS for instance during their teachers training services.

References

Castillo, J. J. (2009). Snowball sampling. Retrieved [Date of Retrieval] from Experiment Resources: http://www.experiment-resources.com/snowball-sampling.html

Doherty, M. (1994). Probability versus non-probability sampling in sample surveys, *The New Zealand Statistics* Review March 1994 issue, pp. 21-28.

Eklöf, H., Pavešič, B. J., & Grønmo, L. S. (2014). A Cross-National Comparison of Reported Effort and Mathematics Performance in TIMSS Advanced. *Applied Measurement in Education*, *27*(1), 31-45.

Furner, J. M., Yahya, N., & Duffy, M. L. (2005). Teach mathematics: strategies to reach all students. *Intervention in School and Clinic*, 41(1), 16-23.

Heckathorn, D. D. (1997). Respondent-driven sampling: A new approach to the study of hidden populations. *Social Problems.* 44, 174-199.

Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international mathematics report: Findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades.* Chestnut Hill, MA: TIMSS & PIRLS International Study Centre, Boston College.

National Council of Teachers of Mathematics (NCTM). (2000). Principles and standards for school mathematics. Reston, VA: NCTM.

Patterson, M., Perry, E., Decker, C., Eckert, R., Klaus, S., Wending, L., &Papanastasiou, E. (2003). Factors associated with high schools mathematics in the United States. *Studies in Educational Evolution*, 29, 91-108.

Ross, K. N. & Genevois, I. J. (eds.) (2006). Cross-national studies of the quality of education: Planning their design and managing their impact. Paris: IIEP, UNESCO.

Seale, C., Gobo, G., Gubrium, J. F., & Silverman, D. (Eds.). (2004). *Qualitative research practice*. London: Sage Publications.

TIMSS (1999), Trends in international mathematics and science study, International Associations for the Evaluation of Educational achievement, From http://timssandpirls.bc.edu/timss1999.html

TIMSS (2003), Trends in international mathematics and science study, International Associations for the Evaluation of Educational achievement, From http://timss.bc.edu/timss2003.html

TIMSS (2007), Trends in international mathematics and science study, International Associations for the Evaluation of Educational achievement, From http://timss.bc.edu/timss2007/intl_reports.html

TIMSS (2011), Trends in international mathematics and science study, International Associations for the Evaluation of Educational achievement, From http://timss.bc.edu/timss2011/