The TIMSS Grade 8 Student's Science Achievement: A Comparative Study between Malaysia, Singapore, and Japan

Nur Sahrizan Serman[1], Corrienna Abdul Talib[2#], Faruku Aliyu[3] & Marlina Ali[4]

[1, 2#,4] School of Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia

[3] Faculty of Education, Sokoto State University, Sokoto, Nigeria

[#]corresponding author <corrienna@utm.my>

Received first draft 24 January 2020. Received reports from the first reviewer (4 April); second reviewer (23 July). Received revised draft 14 October. **Accepted** to publish 23 November 2020.

Abstract

When measuring the quality of education of a nation, it is necessary to consider the global standard and preference. Owing to this reason, Trends in International Mathematics and Science Study (TIMSS) is an international body that regularly carries out an international comparative study to measure the participating countries' achievement in mathematics and science for 8th-grade students in an effort to evaluate International Educational Achievement. Malaysia, Singapore, and Japan joined the program in an attempt to drive the benefits of the assessment and know the level of quality of their mathematics as well as science education referenced to global standards and perspectives. This study employed the use of secondary data obtained from the official website and database of TIMSS 2015. After analyzing the data, Singapore and Japan were spotted as the top two Asian countries that outperformed in science grade 8 of TIMSS 2015 with an average score of 597 and 571 respectively, while Malaysia was reported as 24th on the list standing below-average with a score of 471 compared with the two countries topping as 1st and 2nd positions. Some of the possible reasons are that; while Singaporean students and school administrator resilient and persistent having curriculum emphasizing spirit and scientific inquiry as well as Japanese parental education and early educational goals for student interest in science contribute are seen as factors that help them achieve a higher ranking in TIMSS. It was concluded that Malaysian students also have the potentials of getting to the top position if they emphasize the critical curriculum components of both Singapore and Japan as well as how it was implemented. This study implies that the structure of the 8th-grade Malaysian science curriculum and how it is implemented needs to be reviewed for better productivity and enhancement of science students' achievement.

Keywords: TIMSS; Grade 8; Science students; Achievement

Introduction

Trends in International Mathematics and Science Study (TIMSS) is an international comparative study that has been employed by the International Association to evaluate

International Educational Achievement (IEA). The exercise started since around 1995 which aimed at assessing the quality of the teaching and learning of science and mathematics among as well as across the participating countries targeting Grades 4 and 8 students. It was designed in the form of large-scale assessment to inform the educational policy and practice through generating international perspectives on the general processes of teaching as well as learning mathematics and science (Martin, Mullis, Foy, & Hooper, 2016). TIMSS's goal is to provide joined countries with information to make improvements in curriculum and most specifically teaching as well as learning of mathematics and science. Thus, TIMSS serves as a benchmark for many countries including Malaysia, Singapore, and Japan particularly regarding the performance of students in comparison to their counterparts of similar age and grade level in terms of thinking processes (Ismail, Samsudin, Ismail, & Halim, 2017).

TIMSS aimed at providing vital information to educational practitioners and policymakers about the quality of educational and other relevant systems identifying what happened with the processes of education. It points out the differences between educational levels and educational effects in terms of achievement. This development enables a nation to know what happened elsewhere concerning the educational inputs, conditions, and processes regarding different grade levels in schools as well as other key components of implementing the curriculum such as student, teacher, classroom and other school's needs (Bos, 2002). Furthermore, TIMSS analyses and reports the factors of educational processes revealing the achievement within the international comparative context. The comparative analysis could be used to measure benchmarking, description, monitoring the quality of education about the global standard, perspective and preference, understanding the reason for observed differences if any, and cross-nation research. The outline significances of TIMSS attracted the attention of both developed nations like Singapore and Japan as well as the developing nation such as Malaysia which lead them joined the international trend of study.

While Malaysia joined TIMSS in 1999 with only eight grade which is 14 years old, both Singapore and Japan were part of the program since 1995 which marks the beginning of the program. The pattern results have revealed a decline with regards to Malaysian lower secondary school student's achievement (Ministry of Education, 2013). Malaysia scores keep dropping in TIMSS in succeeding years 1999, 2007 and 2011 for both mathematics and science, indicating that there is an issue with a system of teaching as well as learning of mathematics and science. This called for intervention from the Malaysian Ministry of Education to analyze the problems with science as well as mathematics education most specifically teaching and learning to improve the overall results. Part of the effort is to enhance students' performances in mathematics and science. Referenced to this development, the Malaysian Ministry of Education (2013) advocated for the integration of High Order Thinking Skills (HOTS) in the teaching as well as learning of mathematics and science (Nor'ain & Mohan, 2016). These skills are deemed of a significant role in doing well in the TIMSS assessment.

TIMSS gradually gets recognized across the globe as about fifty-seven different countries and seven benchmarking centres (regional jurisdictions of countries such as provinces or states) participated in TIMSS 2015. In summary, more than 580,000 students participated in TIMSS 2015 (Mohtar, Halim, Samsudin, & Ismail, 2019) which was the sixth assessment in the TIMSS series marking 20 years of trends in educational achievement. The trends give a profile of the countries' achievement so far along with comprehensive data on students' learning of mathematics and science. Based on the profile, Singapore and Japan were spotted as the top two Asian countries that outperformed in science grade 8 in TIMSS 2015. In contrast, Malaysia was reported low on the list in the same science grade 8 standing below-average scores even though it recorded a slight improvement in scores compared to TIMSS 2011 (Martin et al., 2016). Even with the improvement in TIMSS 2015 by Malaysia, the performance is not as expected.

From Figure 1, it could be concluded that there was a steady rise in achievement scores in both Singapore and Japan when Malaysian scores continue to drop.

Figure 1. Scores of students' science achievement in grade 8 for the three countries by years (Michael, Ina Pierre, & Martin, 2015).

Even though a difference could be observed from Figure 1 that Malaysian students' performance in TIMSS suddenly dropped from a score of 510 in 2003 to 471 in 2007 and 426 in 2011, while the two countries (Singapore and Japan) recorded continuing rise in scores. This is a source of concern coupled with the Malaysian government's efforts and advocacy for the integration of HOTS in the teaching and learning of science as well as mathematics, there was still very limited literature to describe the actual discrepancies among the three countries and what made Malaysia performing below average at a time when her two counterparts Singapore and Japan were topping in the Asian countries in TIMSS 2015. Hence, this study aims to compare the science achievement of Malaysian students with their counterparts from Singapore and Japan concerning TIMSS 2015. In a more specific term, the following research questions would guide the study:

1. How well did 8th-grade students in Malaysia achieve in science compared to Singapore and Japan?

2. How did Malaysia, Singapore and Japan implement their science 8th-grade curriculum?

Methodology

This study employed the use of secondary data that were downloaded from the official website and database of TIMSS 2015. The analyses of data revealed the enrolment and achievement of Grades 4 and 8 students of the participating countries in science and mathematics available at IEA (2019). After obtaining the record from the database, profiles of Malaysia, Singapore, and Japan were sorted and presented in tabular form under the results section of this study. The measure of the science achievement represents the three countries' TIMSS 2015 study based on 172 items with science content (comprising Biology, Chemistry, Physics, Earth Science) and cognitive (i.e., Knowing, Applying, Reasoning). The study also utilizes document analysis where both Singaporean and Japanese 8th-grade science curriculum content and emphasis were analysed.

Results and Discussions

The results of the analysis were presented in the following tables. Table 1 showed the number of Grade 8 enrolled in science from Malaysia (N = 9,726), Singapore (N = 6,116) and Japan (N = 4,745). This gives a total of 20,587 students who participated in TIMSS 2015 science assessment.

Table 1
Enrolment in TIMSS 2015 by Country

Country	Total Enrolment
Malaysia	9,726
Singapore	6,116
Japan	4,745
Total	20,587

Research Question One:
How well 8th-grade students in Malaysia achieved in science compared to Singapore and Japan?

This research question was responded to using results in Table 2 and Table 3.

Table 2 revealed that Malaysia has an overall science average score of 471 in TIMSS 2015, with higher scores of 480 and 473 in physics and chemistry respectively. The scores for biology and earth science show only 466 and 460 respectively.

Table 2
Science Achievement Grade 8 in TIMSS 2015

Rank	Country	Average Scale Score for content domains				Overall
		Biology	Chemistry	Physics	Earth Science	Average
1	Singapore	609	593	608	565	597
2	Japan	570	570	570	574	572
24	Malaysia	466	473	480	460	471

On the other hand, Singapore and Japan's overall scores are 597 and 572 respectively. In Singapore, a score of 609 in biology is the highest and least score of 565 in earth science while Japan scores the highest score of 574 in earth science and the least score of 570 for biology, chemistry, and physics (Table 2). This revealed that the least scores in all the two countries (Singapore and Japan) are higher than the highest score in the context of Malaysia.

Figures 2 revealed that Malaysia was found to score less than 500 points in all the four components of science (Biology, Chemistry, Physics, and Earth Science) with an average of 471 in science achievement of grade 8 TIMSS 2015. The scores ranked Malaysia 24th in the year which is quite below average compared to both Singapore and Japan with an average of 597 and 572 ranked 1st and 2nd positions respectively.

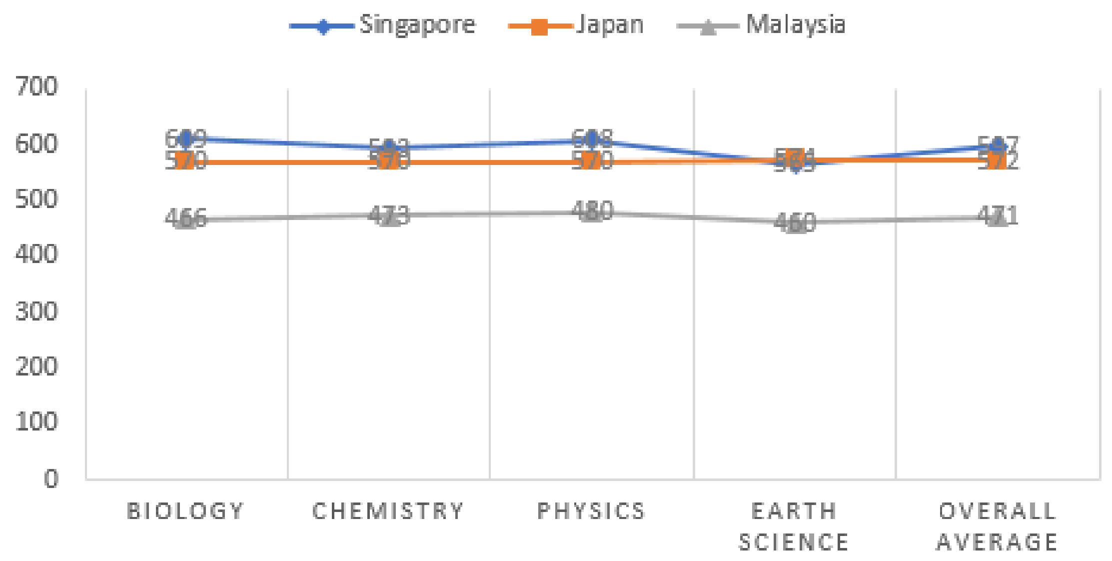

Figure 2. Scores of students' science achievement in grade 8 for the three countries.

A further comparison was made regarding gender and average science achievement among the three countries in grade 8 TIMSS 2015. The results of the analysis were presented in Table 3.

Table 3
Average Science Achievement by Gender in Science 8th-grade TIMSS 2015

Rank	Country	Female		Male	
		Percentage of Students (%)	Average Scale Score	Percentage of Students (%)	Average Scale Score
1	Singapore	49	596	51	597
2	Japan	51	571	49	570
24	Malaysia	50	476	50	466

In TIMSS 2015, the 8th-grade science achievement in Japan and Malaysia based on gender indicated that female students outperformed their male counterparts even though it was very slightly particularly in the case of Japan. However, in Singapore, the outcome was different where male students exceeded their female colleagues with one point as indicated in Table 3.

A comparison is also illustrated further in Figure 3.

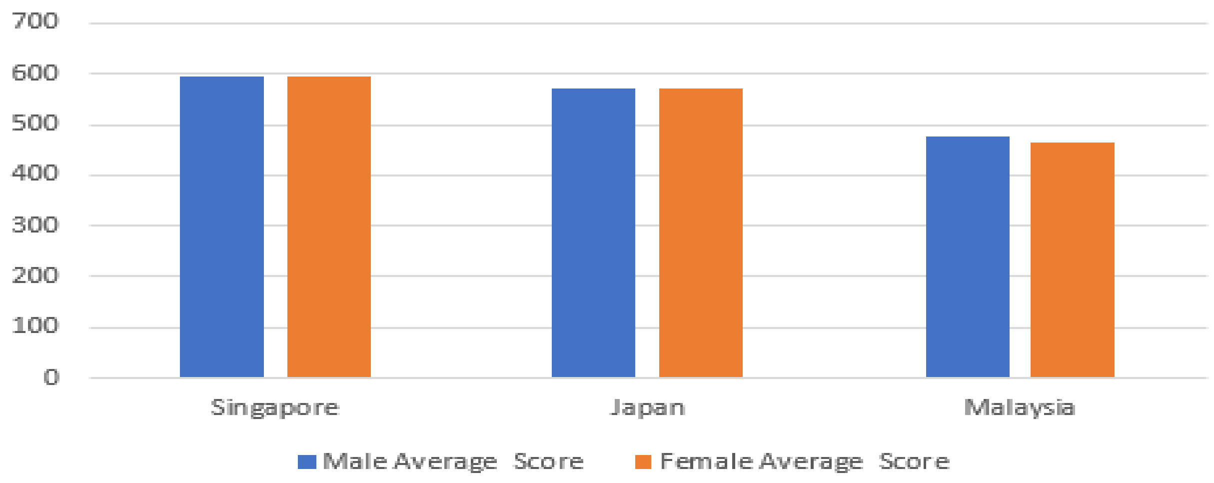

Figure 3. Average science achievement by gender in science grade 8 TIMSS 2015.

Figure 3 revealed that there is a slight difference in the achievement of grade 8th students in science even though not very significant. The result of Malaysia and Japan is a depiction of general patterns of data of 14 countries (Saudi Arabia, Bahrain, Oman, Kuwait, Qatar, United Arab Emirates, Finland, Iran, Islamic Rep. Morocco, Bulgaria, Sweden, Indonesia, Kazakhstan, Georgia, and New Zealand), where female students recorded higher achievement, while that of Singapore coincides with the results of 5 countries (i.e., United States, Chile, Hong Kong, Italy, and Hungary) where male students had higher achievement. The results of the analysis of all three countries are not in the conformity with the majority of the countries that there is no difference between male and female students in the average science achievement.

Research Question Two:
How did Malaysia, Singapore and Japan implement their science 8th-grade curriculum?

This research question was responded to by analysing the nature and emphasis of Malaysian Singaporean and Japanese science 8th-grade curriculum.

Malaysian Grade 8 Science Curriculum

The Malaysian science curriculum for grade 8 is compatible with its National Education Philosophy that aims at nurturing science and technology through the development of learners who are dynamic, competitive, resilient, robust and scientifically and technologically competent.

The curriculum seeks to inculcate:

1. Virtuous values and love for the nation and its citizens
2. Producing active learners with ample opportunities for observing, formulating and testing hypothesis, interpreting data and reporting and evaluating findings
3. Knowledge and skills to solve problems and decide everyday life that requires scientific attitude and core values.
4. Spirit of concerned, dynamic and progressive individual that work toward preservation and conservation of the environment (Curriculum Development Centre, 2003).

The emphasis was given to problem-solving, reasoning, making a connection, mathematical reasoning and use of technology.

Singapore Grade 8 Science Curriculum

The Singapore Grade 8 science curriculum is designed and structured across the spirit as well as practices of scientific inquiry involving:

(1) knowledge, understanding and application of science practice involving scientific phenomena, concepts, facts, principles, vocabulary, conventions, terminologies, instruments, apparatus, techniques, and safety;

(2) processes, and skills; observing, questioning, comparing, classifying, formulating a hypothesis, predicting, testing, analyzing, inferring, communicating, evaluating, creative problem solving, decision-making; and

(3) ethics and attitudes such as curiosity, creativity, objectivity, integrity, open-mindedness, perseverance and responsibility (Singapore Ministry of Education, 2008 & 2013).

The curriculum aimed at enabling students to pursue and appreciate the knowledge as well as skills in science as useful and meaningful. Critical thinking and a creative mind are encouraged through inquiry teaching. This teaching strategy posed questions and ideas that are related to the role science plays in daily life, society, and the overall environment.

According to Andres and Piotr (2016), Singapore continuously recorded high ranking in TIMSS since its inception because the Singaporean educational system seemed very different in terms of the amount of time spent on both science and mathematics homework. The results showed that time spent on mathematics and science homework was associated with high achievement. The advantages of Singaporean students have is that the test language being spoken at home shows a positive impact on student performance in TIMSS. Also, Ong (2015) pointed out that a few steps are taken that yielded remarkable result in turning around the under-performing schools in Singapore were through the experienced 'turnaround' principal who brightened up the school, thereby enhancing the school-community relationship and institutionalizing best practices.

Japan Grade 8 Science Curriculum

The overall objectives of the Japanese science curriculum at the lower secondary level (Grades 7 to 9) centred on the following:

- enabling students to have an active interest in natural things, issues and phenomena;
- making observations and carrying out experiments with a sense of purpose;
- developing the ability of scientific investigations;
- inculcating a positive attitude toward the investigations;
- deepening understanding of natural things, issues and phenomena;
- developing scientific skills as well as inquiry in observation and thinking (Ministry of Education, Culture, Sports, Science and Technology, 2008).

These objectives were designed to be achieved through small group discussions using inquiry. Lilia et al. (2019) observed that Japanese education emphasizes nurturing through respectful discussion in small groups for science right from preschool. The effort aimed at getting a functional model or ideal science lesson in schools. Hence, inculcating students' interest in science right from early childhood is of paramount importance.

Japan was reported as 2^{nd} best in 2015 TIMSS ranking next to Singapore among Asian countries (Andres & Piotr, 2016). The good ranking in TIMSS may be as a result of the efforts the country made in improving the science teaching and providing a functional model of teaching in science class. This can be explained by considering Japan as being greatly inspired by Confucian-heritage culture (CHC) emphasizing effort, diligence, academic achievement, and the value placed on education for both personal, family, and Societal developments and expectations (Li, 2012). In addition, it is also a common practice among students to compete due to strong extrinsic and social status goals.

Comparatively, the aims, objectives and direction of the grade 8 science curriculum in the three countries (Malaysia, Japan, and Singapore) are similar and targeting same purposes as their curriculums are focused on the development of individual on processes and skills to observe, question, compare, classify, formulate a hypothesis, predict, test, analyze, infer, communicate, evaluate situations, and solve the problem.

On the contrary, the time spent on mathematics and science homework is less compared to that of Singapore. Japan has a functional model or ideal science lesson in schools compared to Malaysia. One of significant difference between Malaysia and Singapore in terms of the science curriculum implementation contributes to TIMSS achievement is on the depth each science topic is treated and covered and the level where that topic is introduced (Ibrahim & Othman, 2010). Even with this emphasis by the curriculum Malaysian science teachers tend to adopt spoon-feeding to prepare students for examinations and other assessment (Mohtar, Halim, Samsudin, & Ismail, 2019). Unlike Malaysia teachers both Singapore and Japan, teachers adopt a problem-solving routine and explaining to promote higher-order thing skills to prepare students for assessment (Lay & Chandrasegaran, 2016). By implication, Malaysian teachers need to switch from spoon-feeding strategy to real problem-solving and high order thinking skills development as a better strategy to prepare students for TIMSS and other assessment. Also, there is a need for improvement in the pedagogical content knowledge among the Malaysian teachers compared to Japan and Singapore for better improvement in their achievement in science and mathematics. This assertion was earlier reported by Halim and Meerah (2002) that there is a need for the Malaysian teachers to improve their pedagogical content knowledge and strategies for enhancing students' high order thinking skills.

Conclusion

It can be concluded Singapore and Japan as leading countries in TIMSS have their uniqueness in education that can be followed by another country for improvement. The resilient and persistence of Singaporean student and school administrator coupled with the nature of their curriculum involving spirit and practice of scientific inquiry are seen as among the factors that helped them have a higher ranking in TIMSS. On the other hand, Japanese parental education and early educational goals for student's interest in science accompanying their functional model for ideal science class contribute as a factor that defends their top ranking in TIMSS. Adapting the curriculum content and how it is implemented in the context of the two countries may seem very crucial in raising the status and position of Malaysian students in future TIMSS assessments. This implementation is respect of the amount of time spent in teaching content and the level at which the content is introduced. Japan has a functional model or ideal science lesson in schools that could be adopted by Malaysia. Malaysian science teachers need to avoid spoon-feeding to prepare students for examinations and other assessment but rather follow the suit of both Singapore and Japan teachers adopt a problem-solving routine and explanation to promote high-order thing skills to prepare students for assessment. Also, there is a need for Malaysian teachers to improve their pedagogical content knowledge and strategies for enhancing students' high order thinking skills.

References

Andres, S., & Piotr, B. (2016). Factors and conditions promoting academic resilience: ATIMSS-based analysis of five Asian education systems. *Asia Pacific Educ. Rev. 17*,511-520.

Bos, K. T. (2002). *Benefits and Limitations of Large-Scale International Comparative Achievement Studies: The Case of IEAs/TIMSS study*. Enschede: Ipskamp Partners Print.

Curriculum Development Centre（2003). *Science Syllabus*. Kuala Lumpur, Malaysia: Ministry of Education.

Ibrahima Z. B., & Othman, K. I, (2010). Comparative study of secondary mathematics curriculum between Malaysia and Singapore. *Procedia Social and Behavioral Sciences 8* , 351–355.

IEA (2019). *TIMSS 2015 International Reports*. Boston College, Lynch School of Education: TIMSS and PIRLS International Study Center. Retrieved October 17, 2020 from http://timssandpirls.bc.edu/timss2015/international-results/

Halim, L., & Meerah, S. M. (2002). Science trainee teachers' pedagogical content knowledge and its influence on physics teaching. *Research in Science & Technological Education, 20*(2), 215-225.

Ismail, M. E., Samsudin, M. A., Ismail, A., & Halim, L. (2017). Factors related to science achievement in TIMSS Malaysia: A Confirmatory Factors Analysis. *Man in India Serials Publications, 97*(2), 873-888.

Lay, Y. F., & Chandrasegaran, A. L. (2016). Availability of school resources and TIMSS Grade 8 students' science achievement: A comparative study between Malaysia and Singapore. *International Journal of Environmental & Science Education, 11*(9), 3065-3080.

Li, J. (2012). *Cultural foundations of learning: East and West*. New York: Cambridge University Press.

Michael, O. M, Ina, V.S. M., Pierre, F. & Martin, H. (2015). *Trends in International Mathematics and Science Study: 2015 International Results in Science*. Lynch School of Education, Boston College: International Study Center.

Martin, M. O., Mullis, I. V. S., Foy, P., & Hooper, M. (2016). *TIMSS 2015 International Results in Science.* Retrieved from Boston College, TIMSS & PIRLS International Study

Ministry of Education, Culture, Sports, Science, and Technology. (2008). *Guidelines for teaching junior high school in Japan* (English version). Retrieved November 23, 2020 from http://www.mext.go.jp/a_menu/shotou/new-cs/youryou/eiyaku/1298356.html

Ministry of Education. (2013). *Malaysia Education Blueprint 2013-2025 (Preschool to Post-Secondary Education)*. Putrajaya, Malaysia: Kementerian Pendidikan Malaysia.

Mohtar, L. E., Halim, L., Samsudin, M. A., & Ismail, M. E. (2019). Non-cognitive factors influencing science achievement in Malaysia and Japan: An analysis of TIMSS 2015. *EURASIA Journal of Mathematics, Science and Technology Education, 15*(4), page numbers?

Nor'ain Mohd Tajudin & Mohan Chinnappan. (2016). The link between higher order thinking skills, representation and concepts in enhancing TIMSS tasks. *International Journal of Instruction, 9*(2), 199-214.

Ong, C. H. (2015). Challenges and Processes in School Turnaround A Singapore Secondary School Principal's Perspective. *Procedia -Social and Behavioral Sciences 186(2105) 169-173.*

Singapore Ministry of Education. (2008). *Science syllabus primary 2008.* Retrieved November 23, 2020 from https://www.moe.gov.sg/docs/default-source/document/education/syllabuses/sciences/files/science-primary-2008.pdf

Singapore Ministry of Education. (2013). *Science syllabus primary 2014*. Retrieved January 7, 2020 from https://www.moe.gov.sg/docs/default-source/document/education/syllabus