



CORRELATES OF SCIENCE CLASSROOM TEACHING WITH SOUTHEAST ASIAN AND EAST ASIAN EIGHTH GRADERS' SCIENCE ACHIEVEMENT IN TIMSS 2015

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Abstract

Trends in International Mathematics and Science Study (TIMSS) is an international comparative study that has been implemented by the International Association for the Evaluation of Educational Achievement (IEA) since 1995. This proposed study is aimed to identify the correlations of science classroom teachings with eighth graders' science achievement in TIMSS among Southeast Asian and East Asian countries. The freely downloadable secondary data were analyzed using IEA's International Database (IDB) Analyzer (version 4.0) for TIMSS, a plug-in for SPSS. TIMSS uses an imputation methodology, involving plausible values, to report student performance. This study found that countries with higher average science achievement allocated higher percentage of educational hours for science teaching, students were taught the TIMSS science topics, students attended schools with science laboratories and have assistance available when conducting experiments, computer availability during science lessons, with science teachings were not limited by student needs, and less frequency of student absences. Based on the research findings, policy recommendations were made to the Malaysian Ministry of Education to boost Malaysian eighth graders' science performance in the forthcoming TIMSS assessments.

Keywords: TIMSS, comparative study, classroom teachings, science achievement

Introduction

Students' home and school environments, as well as science teachers' preparation, can significantly affect science teaching effectiveness. However, the classroom environment where students' daily learning activities are directed, and in which students are motivated and develop skills as they interact with their peers, is more likely to have a direct effect on student learning, i.e., the core of classroom teachings. Hence, classroom teaching that provides a good learning environment for the students can be a significant factor for students' academic achievement.

There are many factors that affect science classroom teaching. Students' attitudes toward science, time allocation for science teaching, students' readiness to engage in the science teaching and the resources used by the science teachers can all influence classroom teachings.

In the Philippines, localization of the K-12 enhanced basic curriculum has been reflected in language usage and the medium of instruction (Morales, 2016). Besides that, senior high school curriculum is now more reflective of local and responsive curriculum. Since student motivation is an important factor of students' achievement in science subjects, it is vital to

create a positive outlook in students. Students' attitude towards science is not only formed in their school setting but carried over to their home setting where their culture, practices and native language facilitate their learning (Morales, 2016). In Portugal, Content and Language Integrated Learning (CLIL), a language-aware and content-directed educational approach which integrates different curricular fields, is proposed as a possible solution to provide an authentic learning of both English and Science (Piacentini et al., 2019). Therefore, classroom teaching also needs to be culturally sensitive and as close to the students' natural language as possible in order to facilitate the students to make meaning of their learning (Piacentini et al., 2019). In Malaysia, language is still an issue of debate and the government is urged to seriously think about revert to English as a medium of teaching for teaching science and mathematics to avoid children being left behind internationally (Sonia, 2021).

Trends in International Mathematics and Science Study (TIMSS)

The International Association for the Assessment of Educational Achievement (hereafter abbreviated as IEA) pioneered international comparative evaluation of educational achievements in the 1960s as an attempt to get a deeper understanding of the impact of educational policies and procedures across various school systems. Trends in International Mathematics and Science Study (hereafter abbreviated as TIMSS) as one of the international comparative assessments, is directed by IEA's TIMSS & PIRLS International Study Center at Boston College.

TIMSS seeks to help the participating countries make better decisions on how to improve mathematics and science by teaching and learning. Since 1995, TIMSS is a regular student assessment program in grades four and eight which has been administered every four years. TIMSS provides participating countries with a wealth of information about trends in the science as well as mathematics knowledge and skills of their respective students. At the heart of TIMSS is a wide-ranging state-of-the-art assessment of how well students master the essential science and mathematics content, concepts, as well as procedures that countries expect them to learn as they progress through primary and lower secondary school. Numerous studies were conducted, e.g., in making comparison of eighth graders of East Asian countries in TIMSS 2011 (Lay et al., 2015) but the correlates of science classroom teachings with Southeast Asian and East Asian in TIMSS 2015 has not yet been studied.

Problem Statement

Science education, which transcends the pervasive divide between natural sciences and social sciences, is potentially unique in its ability to promote the awareness and participation of new generations as well as to address the social, economic, and environmental aspects of global challenges. Therefore, addressing diversity and equity-related priorities of science education is of vital significance in the light of the global picture of a rapidly evolving world. This study is unique due to the fact that this is an international comparative study to compare and contrast the correlates of science classroom teaching with Southeast Asian and East Asian eighth grade students' science achievement in TIMSS 2015. Policy recommendations to the Malaysian Ministry of Education will be made based on the success stories of TIMSS top performing countries in Southeast Asia and East Asia in an effort to boost Malaysian eighth graders' science performance in the forthcoming TIMSS assessments.

Malaysia joined TIMSS studies since 1999 at the eighth-grade level. Malaysia with a mean score of 492 was ranked 22nd place in 1999 among 38 participating countries, 21st place in 2003 among 46 participating countries with a mean score of 510, 21st place in 2007 among 59 participating countries with a mean score of 471, 32nd place in 2011 among 63 participating countries with a mean score of 426, and 24th place in 2015 among 63 participating countries with a mean score of 471 (Table 1).

Table 1
TIMSS (Grade 8) Science Scores for Southeast Asian and East Asian Countries (1995 – 2015)

Year	No. of participating countries	TIMSS science scores of grade 8 students							Average
		Malaysia	Singapore	Thailand	Japan	Korea	Hong Kong, SAR	Chinese Taipei	
1995	45	-	580	-	554	546	510	-	N.A.
1999	38	492	568	482	550	549	530	569	488
2003	46	510	578	-	552	558	556	571	474
2007	59	471	567	471	554	553	530	561	500
2011	63	426	590	451	558	560	535	564	500
2015	63	471	597	456	571	556	546	569	500

Source: Martin et al. (2016a); Mullis, 2013; Mullis et al. (2016)

The results of the latest TIMSS 2015 cycle indicated that at the fourth and eighth grades, Singapore, Korea, and Japan are the best ranked nations in science and mathematics education. Table 1 shows the TIMSS science scores for Southeast Asian and East Asian eighth grade students from 1995 to 2015.

Literature Review

Time Spent on Science Teaching

Class time for science teaching is a key indicator of opportunity to learn (Blank, 2012). In the study by Blank (2012), educational factors in elementary science were examined alongside teaching time including types of teaching practices, curriculum emphasis, and teacher preparation, and time using hands-on science activities which showed a positive correlation to National Assessment of Education Progress (NAEP) science scores in America. However, average classroom teaching time was the strongest educational factor related to achievement at the state level (Blank, 2012). In addition to physical resources, the education system's human resources also play a crucial role in students' academic outcomes (Trinidad, 2020). In developing countries teachers may be absent or do not devote enough time on teaching tasks and may be encouraged with incentives and accountability structures (Duflo et al., 2012).

Percentages of Students Taught the TIMSS Science Topics

The most prominent teaching challenge concerns topics to include in the curriculum (Linn et al., 2016). According to Linn et al. (2016) students face a difficulty to make meaning of their learning when confronted with many distinct topics in a single year. Science teachers also face the challenge of sequencing science topics in the curriculum to ensure that students have the prerequisite knowledge, are developmentally ready to learn the material, and can integrate new ideas with prior knowledge (Linn et al., 2016). Moreover, curriculum topics in science might also be taught or omitted based on the available natural resources, topography, or climate in a specific country (Daus & Braeken, 2018).

However, fair comparisons of educational systems in large-scale assessments can be made only if the differences in curricula have little impact on the outcomes (Daus & Braeken, 2018). The assessment framework in TIMSS is centered around a shared curriculum across the

participating countries (Mullis, 2013). From this perspective, curriculum implementation, focus, and sequencing would be crucial for valid and contextualized interpretations of correlations between educational inputs and outcomes. With more than 40 countries participating in TIMSS, it is normal that most countries deviate from the commonly agreed-upon curriculum-based assessment framework. For instance, only half of the participating countries have covered reproduction, heredity and genetics, and human health by grade 8 (Mullis et al., 2016, p. 13). In the study by Daus and Braeken (2018), no support was found for a positive relationship between opportunity to learn and science achievement.

Teachers Emphasize Science Experiment

Engaging students in inquiry teaching and learning featuring interactive models and collaborative activities is vital in assisting average achievers to improve their goals and perceptions of their learning environment (Kuo et al., 2019). Inquiry projects allow the exploration of student ideas while encouraging learners to consider alternatives (Liu et al., 2014). Students can take advantage of scientific visualizations and generate their own explanations and other scientific artifacts. Hands-on activities and conceptual understanding increased average students' motivation while teachers and peers' assistance helped improve low achievers' motivation (Kuo et al., 2019). Thus, inquiry-based teaching offers opportunities for continuous, embedded assessment and personalized guidance. Inquiry projects can also promote collaboration in small groups or among whole classes (Piacentini et al., 2019). They can focus on societal issues in local communities and on global problems that resonate with students' interests and experience (Liu et al., 2014).

Resources for Conducting Science Experiments

A non-statistical relationship between per-pupil expenditure (PPE) and pupils' achievement is reported in (Hedges et al., 2016) based on a meta-analytic review. However, the statistical models used to examine the relationship between school inputs and student outcomes are not consistent across studies and do not support causal inferences. The researchers conclude that PPE may not be related to academic achievement (Hedges et al., 2016). In a study by Connor et al. (2017) researchers found that improving academic knowledge, also improved students' oral and reading comprehension. The Content-Area Literacy Instruction (CALI) Science unit was developed using the 5-E learning cycle: Engagement, Exploration, Explanation, Elaboration and Evaluation (Bybee, 1997 in Connor et al., 2017). During the CALI program pupils used the scientist notebook to keep their written work including graphic organizers. Researchers used hands-on experiments and trade science texts and encouraged students to work in groups to read the book or conduct their experiments. Students then completed their worksheets by responding to questions and recording observations (Connor et al., 2017). Connor et al. (2017) found that students randomly assigned to CALI improved in their achievement for social studies and science post-tests. The availability of contextual support also facilitates student independence in their inquiry science work and science learning (Rappolt-Schlichtmann et al., 2013).

Lay and Chandrasegaran (2016) reported that in Malaysia, on average, 69% of the eighth-grade students attended schools where teaching was Somewhat Affected by resource shortages, 18% attended schools where teaching was Not Affected, and 14% attended schools where teaching was affected a lot by resource shortages. According to Lay and Chandrasegaran (2016) students in schools that were affected a lot by science resource shortages had lower science achievement ($n = 422$) than students in schools that were Not Affected ($n = 454$).

Computer Activities during Science Lessons

Use of ICT tools and computer in science lessons has become quite common in the digital era since the starting of 21st century and the frameworks for ICT policy was developed with exemplars reported by scholars and researchers (Adomi, 2011). In Rappolt-Schlichtmann et al. (2013) but the tasks of recording, organizing, analyzing, and interpreting data create barriers that impede science learning for many students. This study (a web-based science notebook designed using the Universal Design for Learning (UDL) framework was tested among 621 fourth grade students in the United States. Teachers observed that students experienced less anxiety when dealing with science experiments as they were provided with all the contextual resources necessary in the web-based notebook. As students complete each part of a science activity, they are reminded through the navigational structure of the UDL science notebook (UDSN) that they are moving through a process of 'plan, get data, explain'. Once students begin to build an explanation for their inquiry experience, they are provided with contextual supports to facilitate, guide, and then reinforce the process behaviors necessary for effective science notebook use. Students and teachers reported overall quite positive experiences with the notebook, emphasizing high levels of interest, feelings of competence, and autonomy (Rappolt-Schlichtmann et al., 2013) but the tasks of recording, organizing, analyzing, and interpreting data create barriers that impede science learning for many students. This study (a. Thus it can be concluded that appropriate use of computers in science education can improve science content learning outcomes compared with traditional paper-and-pencil science notebooks, and positively impacted student performance (Rappolt-Schlichtmann et al., 2013) but the tasks of recording, organizing, analyzing, and interpreting data create barriers that impede science learning for many students. This study (a. In the advent of digital era, the integration of technology-enhanced learning will also promote values-based sustainable education (Ng, 2007) and enhance the awareness of Sustainable Development Goals (Chin et al., 2018) pertinent in producing quality science related professionals with moral values. Research (e.g., Corrienna et al., 2017; Loganathan et al., 2019) showed that technology-enhanced fun science learning approaches enhanced students' motivation in science learning.

Student Use of Internet for Schoolwork

Starting in the mid-1990 when the cost of information and communication devices became more affordable, and Internet use grew, technology was no longer accessible only to wealthy school districts (Linn et al., 2016). By 2008, there was an average of one computer for every 3.1 public school students in the United States (NCES, 2014). Since then, increasing attention was seen in educational settings in which online learning through Internet was used widely to enhance science learning as reported by Ng and Nyunt (2010). To support science practices, designers created powerful resources rather than adapting tools of scientists, and technology moved from an accessory to an integral partner in science inquiry, enhancing teachers' roles and guiding students' autonomous learning (Linn et al., 2016). Design-based research methods led to exciting refinements of technologies for education (Linn et al., 2016). Today Internet connectivity is a necessary school resource and reflects the quality of educational resources provided in school (Tan, 2018).

Internet connection is also a vital measure of home resources that help to create a conducive environment of learning for children (Visser et al., 2015; Gelmez-Burakgazi & Yildirim, 2014). A study among 735 Turkish parents revealed that most children did not have basic science materials at home (Cobanuglu & Yurttas-Kumlu, 2020). Parental support for children's science learning was examined across three different grade levels including preschool, elementary school and middle school grades in Cobanuglu and Yurttas-Kumlu (2020)(b. Results indicate varying levels of parental support and science materials that can support children's science learning in their home environment. More than half of the middle school children (51.8%)

had access to science-related computer applications at home unlike preschool (36.5%) and elementary school (41.3%) children (Cobanuglu & Yurttas-Kumlu, 2020).

In a survey by Sullivan et al. (2013) Australian school principals reported that the mean number of computers available to 15-year-old students within year 10, across school communities, closely matched the mean number of students within that range. Data also indicates that almost all school computers have Internet access (Sullivan et al., 2013). The analysis includes 353 schools across eight community types that range in size of less than 1,000 people in small country towns to more than 18 million people in large capital cities. Principals reported varying levels of resources including qualified teaching staff, teaching materials and equipment across various geographical locations and these variances were also reflected in students' academic performance (Sullivan et al., 2013).

Weekly Time Student Spend on Assigned Science Homework

The relationship between academic results and homework time is negative at the individual level but positive at school level (Fernández-Alonso et al., 2017). An increase in the amount of homework a school assigns is associated with an increase in the differences in student time spent on homework. In Fernández-Alonso et al. (2017) data indicates that in year 8 of compulsory education, 60–70 min of homework a day is the optimum amount of homework proposed which schools should assign to maximize gains in achievement. Assigning large volumes of homework increases inequality between students in pursuit of minimal gains in achievement for those who least need it (Fernández-Alonso et al., 2017). Assigning an excessive volume of homework at school levels which offer compulsory education could accentuate differences, affecting students who are slower, have more gaps in their knowledge, or are less privileged, and can make them feel overwhelmed by the amount of homework assigned to them (Suárez et al., 2016).

Teaching Limited by Student Needs

Students value the fact that teachers should be alert to their needs, such as being sensitive to students' reactions and preparing additional learning materials (Halim et al., 2014). Students of different achieving abilities would be able to indicate the components of teachers' pedagogical content knowledge (PCK) needed according to their needs. Halim et al. (2014) suggests that teachers need to think about students' difficulties and focus on teaching strategies that enable the students to comprehend the content of science through various modes of concept representational. A student's culture, traditions, practice and native language is his primal need and utility (Tan, 2018). When learning is facilitated with these needs and utilities, the students' attitude may improve while preserving his culture and native language as has been researched by Ng and Ng (2006) on factors contributing to science learning using mother tongue language. Thus, learning should be differentiated according to the learners' needs (Morales, 2016).

In the study by Paufler and Amrein-Beardsley (2014), 1265 principals from Arizona participated in an online survey to explore the decisions principals make when assigning students into classrooms and principals' opinions about randomly assigning students into classrooms. Despite advanced training and prior administrative experience, most principal respondents noted that the assignment of students was not discussed during their professional or administrative coursework. More than 60.0% of students enrolled in almost half ($n = 161/367$, 43.9%) of the schools represented by the participating principals were from racial or ethnic minority backgrounds (Paufler & Amrein-Beardsley, 2014). Most respondents noted that during the assignment process, placement decisions were made based on (i) students' special education needs, (ii) academic achievement or abilities, (iii) gender, and (iv) giftedness, in that order. Principals purported that interactions among students, whether positive or negative, significantly impacted the learning environment in classrooms (Paufler & Amrein-Beardsley, 2014). Results

indicate that principals expected to match students' needs with teacher characteristics such as teaching style, personality and other pedagogical strengths to improve students' achievement (Paufler & Amrein-Beardsley, 2014).

Frequency of Student Absences

Trinidad (2020) found that in terms of school climate deficits, attendance problems were a concern of public and low-SES schools. The attendance problem was more of a problem in urban schools compared to rural schools (Trinidad, 2020). Urban schools also encounter more student discipline problems as compared to rural schools. The study was carried out using 2018 Philippine PISA data ($n = 7233$). More than 40 percent of Philippine schools have problems with student absenteeism to some extent and this could be more strategically addressed in a climate where students know what are expected of them and discipline is applied consistently and appropriately (Trinidad, 2020). According to Andrew and Hauser (2011), there are no adequate tests to prove that students' educational expectations are influenced by their academic achievement and weak evidence of students' educational expectations as static mental drives. Family endowments, and social contexts and influences are more important foundational sources of students' expectations (Andrew & Hauser, 2011).

Research Aim and Objectives

This study aimed to explore the correlations of science classroom teaching with Southeast Asian and East Asian eighth graders' science achievement in TIMSS 2015. The study embarked on the following objectives:

- i) To identify the correlates of science classroom teachings with Grade 8 students' science achievement in TIMSS among Southeast Asian and East Asian countries:
 - time spent on science teaching;
 - percentage of students taught the TIMSS science topics;
 - teacher emphasize science experiment
 - resources for conducting science experiments;
 - computer activities during science lessons;
 - students use of Internet for schoolwork;
 - weekly time student spend on assigned science homework;
 - teaching limited by student needs;
 - frequency of student absences.
- ii) To make policy recommendations to the Ministry of Education to boost Malaysian Grade 8 students' science performance in the forthcoming TIMSS assessments.

Research Methodology

General Background

Data for the study were drawn from the TIMSS 2015 database (<http://timssandpirls.bc.edu/timss2015/international-database/>). TIMSS employs a two-stage stratified sampling approach. First, schools were selected based on the probability proportional to the school's size. The classrooms within the selected schools are randomly chosen afterward. Due to the TIMSS sampling scheme, the surveyed samples can represent the whole population in the participating countries. More information regarding data and sampling procedures of TIMSS can be found in the technical reports by Martin et al. (2016b).

Science Achievement

The science achievement scale of TIMSS 2015 was focused on science subjects like information (Biology, Chemistry, Physics, Earth Science) and cognitive (Knowing, Implementing, Reasoning) domains. To report student results, TIMSS uses a synthetic data approach, which requires plausible values. Realistic values are natural factors from either the set of ratings, consists of a process proposed by Mislevy and Sheehan (1987, 1989) and based on Rubin's principle of imputation (1987) (i.e., random draws from the marginal posterior of the latent distribution used as a measure of science achievement). A plug-in for SPSS, the IEA International Database (IDB) Analyzer for TIMSS, had been used to aggregate the five plausible values and to generate their weighted average and to address standard errors.

Time Spent on Science Teaching

In TIMSS 2015 eighth grade science assessment, the total instructional hours per year and hours per year for science instruction were calculated based on the information provided by school principals and teachers.

Percentages of Students Taught the TIMSS Science Topics

In TIMSS 2015 eighth grade science assessment, percentages of students taught the TIMSS science topics (seven Biology topics, six Chemistry topics, five Physics topics, and four Earth Science topics) were calculated based on teachers' reports.

Teachers Emphasize Science Investigation

In TIMSS 2015 eighth grade science assessment, students were scored according to their teachers' responses to how often they used each of eight instructional activities (BTBS18B, BTBS18C, BTBS18D, BTBS18E, BTBS18F, BTBS18G, BTBS18H, BTBS18L) on the Emphasis Science Investigation scale. Students with teachers who emphasized science investigation in "About Half the Lessons or More" had a score on the scale of at least 11.3, which corresponds to their teachers using all eight activities in "about half the lessons" on average. All other students had teachers who emphasized science investigation in "Less than Half the Lessons". The Cronbach's Alpha coefficients for the Emphasis Science Investigation scale were reliably high [Malaysia, .871; Singapore, .850; Thailand, .885; Japan, .802; Korea, .893; Hong Kong SAR, .841; Chinese Taipei, .883].

Resources for Conducting Science Experiments

In TIMSS 2015 eighth grade science assessment, students were categorized according to their principals' responses concerning availability of resources for conducting science experiments: "Schools Have a Science Laboratory" and "Teachers Have Assistance Available when Students are Conducting Experiments".

Computer Activities During Science Lessons

In TIMSS 2015 eighth grade science assessment, students were categorized according to their teachers' responses concerning computer activities during science lessons: "To Practice Skills and Procedures", "To Look Up Ideas and Information", "To Do Scientific Procedures or Experiments", "To Study Natural Phenomena Through Simulations", or "To Process and Analyze Data".

Student Use of Internet for Schoolwork

In TIMSS 2015 eighth grade science assessment, students were categorized according to their use of Internet for schoolwork: "Access the Textbook or Other Course Materials", "Access Assignments Posted Online by the Teacher", "Collaborate with Classmates on Assignments or Projects", "Communicate with the Teacher", or "Find Information, Articles, or Tutorials to Aid in Understanding Science".

Weekly Time Student Spend on Assigned Science Homework

In TIMSS 2015 eighth grade science assessment, students were categorized according to their weekly time spend on assigned science homework: "3 Hours or More", "More than 45 Minutes but Less than 3 Hours", or "45 Minutes or Less".

Teaching Limited by Student Needs

In TIMSS 2015 eighth grade science assessment, students were scored according to their teachers' responses concerning six needs on the Teaching Limited by Student Needs scale (BTBG15A, BTBG15B, BTBG15C, BTBG15D, BTBG15E, BTBG15G) Students with teachers who felt "Not Limited" by student needs had a score on the scale of at least 11.4, which corresponds to their teachers feeling "not at all" limited by three of the six needs and to "some" extent limited by the other three needs, on average. Students with teachers who felt "Very Limited" by student needs had a score no higher than 7.4, which corresponds to their teachers reporting feeling limited "a lot" by three of the six needs and to "some" extent limited by the other three needs, on average. All other students had teachers who felt "Somewhat Limited" by student needs. The Cronbach's Alpha coefficients for the Emphasize Science Investigation scale were reliably high [Malaysia, .720; Singapore, .732; Thailand, .733; Japan, .716; Korea, .799; Hong Kong SAR, .686; Chinese Taipei, .760].

Frequency of Student Absences

In TIMSS 2015 eighth grade science assessment, students were categorized according to their frequency of absences: "Never or Almost Never", "Once a Month", "Once Every Two Weeks", or "Once a Week or More".

Research Results

Part 1: Analysis of Data in Response to Research Objective 1

(a) Time Spent of Science Teaching

Table 2 summarizes the time spent on science teaching as reported by the school principals in Southeast Asian and East Asian TIMSS participating countries. Based on the analysis, Thailand has the highest total teaching hours per year (1,209.38), followed by Malaysia (1,172.19), Chinese Taipei (1,132.33), and Singapore (1,065.02). In terms of the number of hours (per year) for science teaching, Chinese Taipei has allocated 213.37 hours per year (18.84%) for science teaching. This is followed by Japan (18.61%) and Hong Kong SAR (17.13%). However, Malaysia has only allocated 193.25 hours (16.49%) for science teaching.

Table 2
Time Spent on Science Teaching

Country	Total teaching hours per year	Hours per year for science teaching	Percentage (%)
Malaysia	1,172.19 (15.64)	193.25 (5.62)	16.49
Singapore	1,065.02 (0.00)	171.82 (2.20)	16.13
Thailand	1,209.38 (6.84)	163.89 (2.56)	13.55
Japan	1,036.18 (6.05)	192.79 (2.19)	18.61
Korea	946.60 (6.00)	147.05 (3.33)	15.53
Hong Kong, SAR	995.31 (11.74)	170.47 (4.19)	17.13
Chinese Taipei	1,132.33 (9.70)	213.37 (3.07)	18.84
International Average	1,021 (2.1)	144 (0.7)	

Note. Reported by principals; standard errors appear in parentheses.

(b) Percentages of Students Taught the TIMSS Science Topics

Table 3 illustrates the percent of students taught the TIMSS science topics as reported by the teachers in Southeast Asian and East Asian TIMSS participating countries. Thailand has the highest percentage of students taught the TIMSS science topics (73%), followed by Singapore (68%), and Chinese Taipei (67%). Chinese Taipei has the highest percentage of students taught the Biology and Chemistry topics (89%, respectively). This is followed by Singapore (69%) and Thailand (67%) for Biology as well as Thailand (85%) and Singapore (78%) for Chemistry, respectively. Singapore has the highest (85) percentage of students taught the TIMSS Physics topics (85%), followed by Korea (76%), Japan (73%) as well as Malaysia and Hong Kong SAR with 72%, respectively. Earth Science topics was given the most emphasis by Thailand with 72% of the Thai students have been taught the Earth Science topics, followed by Korea (64%), and Japan (40%). However, there is only 5% of Taiwanese students taught the TIMSS Earth Science topics.

Table 3
Students Taught the TIMSS Science Topics

Country	Percent of students taught the TIMSS science topics				
	All science (22 topics)	Biology (7 topics)	Chemistry (6 topics)	Physics (5 topics)	Earth science (4 topics)
Malaysia	61 (1.5)	64 (1.6)	64 (1.8)	72 (1.7)	37 (2.6)
Singapore	68 (0.9)	69 (1.4)	78 (1.3)	85 (1.0)	28 (2.1)
Thailand	73 (1.1)	67 (2.0)	85 (1.5)	69 (1.5)	72 (1.6)
Japan	60 (0.8)	56 (1.2)	67 (1.1)	73 (1.4)	40 (1.7)
Korea	60 (1.0)	49 (1.6)	59 (1.4)	76 (1.1)	64 (1.5)
Hong Kong, SAR	55 (1.3)	64 (2.2)	46 (1.9)	72 (1.6)	34 (3.1)
Chinese Taipei	67 (1.0)	89 (2.6)	89 (0.7)	61 (1.1)	5 (1.5)
Intern. Avg	73 (0.2)	73 (0.2)	76 (0.2)	72 (0.3)	68 (0.3)

Note. Reported by teachers; standard errors appear in parentheses.

(c) *Teachers Emphasize Science Experiment*

Table 4 shows the descriptive statistics (weighted) with average scale scores for Southeast Asian teachers emphasizing science investigation as reported by science teachers.

Generally, Malaysia has the highest average scale score of 10.38, followed by Thailand (10.12), and Singapore (9.00) in emphasizing science investigation. Malaysia has the highest mean scores for ‘observe natural phenomena and describe what they see’ ($M = 3.16$), ‘conduct experiment or investigation’ ($M = 2.92$), ‘use evidence from experiments or investigations’ ($M = 2.91$), ‘interpret data from experiments or investigations’ ($M = 2.79$), and ‘watch me demonstrate an experiment or investigation’ ($M = 2.66$).

Thailand has the highest mean scores for ‘present data from experiments or investigations’ ($M = 2.80$), ‘design or plan experiments or investigations’ ($M = 2.73$) and ‘do field work outside the class’ ($M = 2.32$).

Table 4
Descriptive Statistics (Weighted) with Average Scale Scores for Southeast Asian Teachers Emphasizing Science Investigation (Teachers’ Reports)

Statement code	Statement	Southeast Asian countries					
		Malaysia		Singapore		Thailand	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Teachers emphasize science investigation (teachers’ reports)							
BTBS18B	Observe natural phenomena and describe what they see	3.16	0.75	2.62	0.71	2.79	0.68
BTBS18C	Watch me demonstrate an experiment or investigation	2.66	0.80	2.47	0.64	2.48	0.70
BTBS18D	Design or plan experiments or investigations	2.61	0.78	1.93	0.69	2.73	0.73
BTBS18E	Conduct experiments or investigations	2.92	0.73	2.37	0.58	2.82	0.72
BTBS18F	Present data from experiments or investigations	2.74	0.72	2.16	0.62	2.80	0.72
BTBS18G	Interpret data from experiments or investigations	2.79	0.69	2.27	0.63	2.77	0.72
BTBS18H	Use evidence from experiments or investigations to support conclusions	2.91	0.74	2.47	0.72	2.84	0.75
BTBS18L	Do field work outside the class	2.06	0.76	1.48	0.59	2.32	0.65
Average scale score		10.38 (0.16)		9.00 (0.09)		10.12 (0.16)	

Note. 1 = Never, 4 = Every or Almost Every Lesson; standard errors appear in parentheses.

Table 5 shows the descriptive statistics (weighted) with average scale scores for East Asian teachers emphasizing science investigation as reported by science teachers.

Generally, Hong Kong SAR has the highest average scale score of 10.13, followed by Japan (9.88), Korea (9.35), and Chinese Taipei (8.93) in emphasizing science investigation.

Hong Kong SAR has the highest mean scores for ‘conduct experiments or investigations’ ($M = 3.07$), ‘use evidence from experiments or investigations’ ($M = 2.82$), ‘interpret data from experiments or investigations’ ($M = 2.75$), ‘observe natural phenomena and describe what they see’ ($M = 2.73$), ‘watch me demonstrate an experiment or investigation’ ($M = 2.62$), and ‘design or plan experiments or investigations’ ($M = 2.28$).

On the other hand, Japan has the highest mean scores for ‘observe natural phenomena and describe what they see’ ($M = 2.73$), and ‘present data from experiments or investigations’ ($M = 2.68$). Korea has the highest mean score for ‘do field work outside the class’ ($M = 1.74$), whereas Chinese Taipei has the highest mean score for ‘design or plan experiments or investigations’ ($M = 2.28$).

Table 5
Descriptive Statistics (Weighted) with Average Scale Scores for East Asian Teachers Emphasizing Science Investigation (Teachers' Reports)

Statement code	Statement	East Asian countries							
		Japan		Korea		Hong Kong, SAR		Chinese Taipei	
		M	SD	M	SD	M	SD	M	SD
Teachers emphasize science investigation (teachers' reports)									
BTBS18B	Observe natural phenomena and describe what they see	2.73	0.70	2.44	0.80	2.73	0.73	2.67	0.78
BTBS18C	Watch me demonstrate an experiment or investigation	2.46	0.68	2.54	0.66	2.62	0.65	2.43	0.66
BTBS18D	Design or plan experiments or investigations	2.10	0.63	2.22	0.73	2.28	0.74	2.28	0.71
BTBS18E	Conduct experiments or investigations	2.91	0.69	2.35	0.67	3.07	0.74	2.30	0.57
BTBS18F	Present data from experiments or investigations	2.68	0.69	2.49	0.70	2.65	0.77	2.23	0.59
BTBS18G	Interpret data from experiments or investigations	2.72	0.68	2.59	0.75	2.75	0.74	2.36	0.65
BTBS18H	Use evidence from experiments or investigations to support conclusions	2.69	0.72	2.65	0.80	2.82	0.75	2.41	0.64
BTBS18L	Do field work outside the class	1.50	0.58	1.74	0.75	1.63	0.61	1.59	0.65
	Average scale score	9.88 (0.13)		9.35 (0.15)		10.13 (0.13)		8.93 (0.14)	

Note. 1 = Never, 4 = Every or Almost Every Lesson; standard errors appear in parentheses.

Table 6 shows the emphasis on science investigation reported by teachers. Malaysia has the highest average scale score of 10.38 followed by Hong Kong SAR (10.13), Thailand (10.12), Japan (9.88), Korea (9.35), Singapore (9.00), and Chinese Taipei (8.93).

Ironically, Singapore has the lowest percentage of students (7.65) in which teachers emphasize science investigation about half the lesson or more, with the highest average achievement of 617.24. However, Singapore has the highest percentage of students (92.35) in which teachers emphasize science investigation less than half the lesson, with the highest average achievement 594.94.

Table 6
Teachers Emphasize Science Investigation (Teachers' Reports)

Country	About half the lesson or more		Less than half the lesson		Average scale score
	Percent of students	Average achievement	Percent of Students	Average achievement	
Malaysia	30.05 (3.44)	477.63 (8.93)	69.95 (3.44)	464.94 (5.72)	10.38 (0.16)
Singapore	7.65 (1.55)	617.24 (15.13)	92.35 (1.55)	594.94 (3.45)	9.00 (0.09)
Thailand	30.95 (4.00)	469.10 (8.89)	69.05 (4.00)	449.91 (5.15)	10.12 (0.16)
Japan	17.85 (3.24)	567.38 (3.71)	82.15 (3.24)	571.78 (2.00)	9.88 (0.13)
Korea	15.95 (2.67)	555.35 (3.31)	84.05 (2.67)	555.64 (2.45)	9.35 (0.15)
Hong Kong, SAR	24.89 (3.56)	565.12 (6.58)	75.11 (3.56)	538.87 (5.00)	10.13 (0.13)
Chinese Taipei	11.13 (2.55)	580.60 (6.26)	88.87 (2.55)	568.08 (2.31)	8.93 (0.14)
Intern. Avg.	27 (0.5)	490 (1.3)	7.3 (0.5)	485 (0.7)	

Note. Reported by teachers; standard errors appear in parentheses.

(d) Resources for Conducting Science Experiments

Table 7 illustrates the resources for conducting science experiments as reported by principals in Southeast Asian and East Asian TIMSS participating countries. Singapore and Hong Kong SAR (with average science achievement of 596.98 and 544.81, respectively) both reported 100% of students attended schools with science laboratories. This is followed by Japan (99.43%) and Korea (99.14%) with average science achievement of 571.04 and 555.68, respectively.

Table 7
Resources for Conducting Science Experiments

Country	Schools have a science laboratory			
	Yes		No	
	Percent of students	Average achievement	Percent of students	Average achievement
Malaysia	98.70 (0.86)	471.32 (4.21)	1.30 (0.86)	432.63 (19.58)
Singapore	100.00 (0.00)	596.98 (3.18)	~	~
Thailand	92.75 (1.91)	456.90 (4.42)	7.25 (1.91)	442.31 (11.03)
Japan	99.43 (0.57)	571.04 (1.81)	.57 (0.57)	546.88 (4.57)
Korea	99.14 (0.70)	555.68 (2.24)	.86 (0.70)	546.17 (12.11)
Hong Kong, SAR	100.00 (0.00)	544.81 (4.16)	~	~
Chinese Taipei	97.62 (1.03)	570.81 (2.09)	2.38 (1.03)	514.60 (27.35)
Intern. Avg.	85 (0.4)	489 (0.7)	15 (0.4)	450 (2.0)

Note. Reported by principals; standard errors appear in parentheses; ~ insufficient data to report achievement.

The analysis results in Table 8 reveals that Hong Kong SAR (98.37%) and Singapore (98.22%) have the highest percentage of students whose teachers have assistance available when students are conducting experiments. Eighth grade students' average science achievement were reported as 544.42 and 597.36, respectively. It is noteworthy that 62.48% and 50.54% of the Japanese and Korean eighth grade students whose teachers have no assistance available when students are conducting experiments, however, students' average science achievement were relatively high at 565.82 and 55.145, respectively.

Table 8
Resources for Conducting Science Experiments

Country	Teachers have assistance available when students are conducting experiments			
	Yes		No	
	Percent of students	Average achievement	Percent of students	Average achievement
Malaysia	88.78 (2.88)	472.19 (4.39)	11.22 (2.88)	459.99 (14.17)
Singapore	98.22 (0.00)	597.36 (3.24)	1.78 (0.00)	575.72 (21.27)
Thailand	21.92 (3.27)	471.78 (10.77)	78.08 (3.27)	451.37 (4.61)
Japan	37.52 (3.94)	579.44 (3.96)	62.48 (3.94)	565.82 (2.34)
Korea	49.46 (3.76)	559.83 (2.92)	50.54 (3.76)	551.45 (3.14)
Hong Kong, SAR	98.37 (1.17)	544.42 (4.18)	1.63 (1.17)	543.37 (11.13)
Chinese Taipei	88.25 (2.32)	571.67 (2.40)	11.75 (2.32)	553.61 (9.50)
Intern. Avg.	58 (0.5)	489 (1.1)	42 (.5)	481 (1.5)

Note. Reported by principals; standard errors appear in parentheses.

(e) Computer Activities during Science Lessons

Table 9 summarizes the availability of computer for students to use in science lessons as reported by principals in the Southeast and East Asian TIMSS participating counties. As shown in Table 9, Japan (55.45%) and Singapore (51.83%) have the highest percentage of students with computer availability in science lessons. Eighth grade students' average science achievement were reported as 571.37 and 592.04, respectively. On the contrary, Malaysia (90.39%) has the highest percentage of students who responded 'No' on the availability of computer for them to use during science lessons with an average science achievement of 466.70.

Table 9
Computer Activities during Science Lessons

Country	Computer available for students to use in science lessons			
	Yes		No	
	Percent of students	Average achievement	Percent of students	Average achievement
Malaysia	9.61 (1.80)	493.48 (8.74)	90.39 (1.80)	466.70 (4.85)
Singapore	51.83 (2.32)	592.04 (4.94)	48.17 (2.32)	601.59 (4.40)
Thailand	49.03 (4.12)	467.51 (6.36)	50.97 (4.12)	444.63 (5.82)
Japan	55.45 (4.16)	571.37 (2.95)	44.55 (4.16)	570.35 (3.23)
Korea	50.39 (3.92)	553.97 (3.26)	49.61 (3.92)	557.25 (2.71)
Hong Kong, SAR	21.27 (3.61)	554.97 (8.88)	78.73 (3.61)	541.93 (4.64)
Chinese Taipei	44.21 (3.75)	573.86 (4.09)	55.79 (3.75)	566.00 (2.83)
Intern. Avg.	42 (0.5)	493 (1.0)	58 (0.5)	483 (0.8)

Note. Reported by principals; standard errors appear in parentheses.

In terms of the computer activities during science lessons, Thailand has the highest percentage of students whose teachers have them use computers at least monthly ‘to practice skills and procedures’ (40%), ‘to look up for ideas and information’ (47%), ‘to do scientific procedures and experiments’ (42%), ‘to study natural phenomena through simulations’ (45%), and ‘to process and analyze data’ (40%). This is followed by Singapore: ‘to practice skills and procedures’ (31%), ‘to look up for ideas and information’ (41%), ‘to do scientific procedures and experiments’ (27%), ‘to study natural phenomena through simulations’ (34%), and ‘to process and analyze data’ (27%). On the contrary, Malaysia has the lowest percentage of students whose teachers have them use computers at least monthly ‘to practice skills and procedures’ (5%), ‘to look up for ideas and information’ (9%), ‘to do scientific procedures and experiments’ (3%), ‘to study natural phenomena through simulations’ (7%), and ‘to process and analyze data’ (4%).

Table 10
Computer Activities during Science Lessons

Country	Percent of students whose teachers have them use computers at least monthly				
	To practice skills and procedures	To look up ideas and information	To do scientific procedures or experiments	To study natural phenomena through simulations	To process and analyze data
Malaysia	5 (1.3)	9 (1.8)	3 (0.9)	7 (1.4)	4 (1.2)
Singapore	31 (2.2)	41 (2.2)	27 (1.8)	34 (2.2)	27 (1.9)
Thailand	40 (4.2)	47 (4.2)	42 (4.0)	45 (4.3)	40 (4.3)
Japan	8 (2.1)	19 (3.2)	11 (2.4)	18 (3.1)	12 (2.2)
Korea	25 (3.2)	30 (3.4)	28 (3.5)	28 (3.3)	26 (3.2)
Hong Kong, SAR	12 (2.9)	17 (3.4)	12 (3.1)	15 (3.1)	14 (2.8)
Chinese Taipei	17 (2.7)	23 (3.0)	26 (3.4)	19 (2.8)	19 (2.6)
Intern. Avg.	30 (0.5)	37 (0.5)	28 (0.5)	29 (0.5)	29 (0.5)

Note. Reported by teachers; standard errors appear in parentheses.

(f) Student Use of Internet for Schoolwork

Table 11 shows the student use of Internet for schoolwork as reported by the eighth-grade students in Southeast Asian and East Asian TIMSS participating countries. The analysis of revealed that Thailand has the highest percentage of students who use Internet to ‘access the textbooks or other course materials’ (81.05%), ‘collaborate with classmates on assignments or projects’ (88.21%), and ‘find information, articles, or tutorials to aid in understanding science’ (75.51%). Singapore has the highest percentage of students who use Internet to ‘access assignments posted online by the teacher’ (90.10%) and ‘communicate with the teacher’ (49.37%). Unexpectedly, Japan has the lowest percentage of students who use Internet to ‘access the textbooks or other course materials’ (22.50%), ‘access assignments posted online by the teacher’ (15.86%), ‘collaborate with classmates on assignments or projects’ (28.45%), ‘communicate with the teacher’ (5.14%), and ‘find information, articles, or tutorials to aid in understanding science’ (32.06%).

Table 11
Student Use of Internet for Schoolwork

Country	Percent of students who use Internet to do the following tasks				
	Access the textbooks or other course materials	Access assignments posted online by the teacher	Collaborate with classmates on assignments or projects	Communicate with the teacher	Find information, articles, or tutorials to aid in understanding science
Malaysia	60.00 (1.14)	27.31 (1.06)	79.61 (0.98)	45.20 (1.21)	72.51 (1.21)
Singapore	56.67 (0.72)	90.10 (0.52)	84.36 (0.66)	49.37 (0.64)	71.39 (0.73)
Thailand	81.05 (0.95)	56.12 (1.66)	88.21 (0.72)	46.50 (1.47)	75.51 (0.92)
Japan	22.50 (0.84)	15.86 (0.88)	28.45 (0.99)	5.14 (0.46)	32.06 (0.84)
Korea	50.77 (1.02)	43.40 (1.26)	68.55 (1.07)	12.82 (0.67)	49.20 (0.93)
Hong Kong, SAR	51.00 (1.32)	63.54 (1.88)	76.43 (1.31)	32.82 (1.19)	64.65 (1.12)
Chinese Taipei	73.65 (0.87)	49.77 (1.14)	71.67 (0.99)	28.34 (1.00)	45.80 (0.84)
Intern. Avg.	56 (0.2)	53 (0.2)	69 (0.2)	36 (0.2)	61 (0.2)

Note. Reported by students; standard errors appear in parentheses.

(g) Weekly Time Student Spend on Assigned Science Homework

Table 12 summarizes the weekly time spent by students on assigned science homework. As illustrated in Table 12, Thailand (11.40%) and Malaysia (11.28%) have the highest percentage of students who spent three hours or more on assigned science homework with average science achievement of 462.80 and 468.20, respectively. 51.97% of the Singaporean students spent more than 45 minutes but less than 3 hours on assigned science homework with an average science achievement of 609.32. This is followed by Thailand (48.08%) and Malaysia (47.18%). On the contrary, East Asian eighth grade students spent less weekly time on assigned science homework. For instance, 91.26% of the Korean students and 84.21% of the Japanese students spent 45 minutes or less on assigned science homework with average science achievement of 556.84 and 576.36, respectively.

Table 12
Weekly Time Student Spend on Assigned Science Homework

Country	3 hours or more		More than 45 minutes but less than 3 hours		45 minutes or less	
	Percent of students	Average achievement	Percent of students	Average achievement	Percent of students	Average achievement
Malaysia	11.28 (0.55)	468.20 (4.85)	47.18 (0.95)	486.42 (3.70)	41.54 (0.99)	463.37 (5.37)
Singapore	9.35 (0.51)	606.39 (3.80)	51.97 (0.91)	609.32 (2.60)	38.69 (1.17)	578.82 (4.86)
Thailand	11.40 (0.77)	462.80 (5.82)	48.08 (1.04)	464.70 (4.31)	40.52 (1.22)	445.89 (4.85)
Japan	1.03 (0.14)	538.80 (11.92)	14.77 (1.41)	560.50 (3.93)	84.21 (1.45)	576.36 (1.97)
Korea	0.89 (0.16)	521.32 (13.32)	7.85 (0.71)	546.44 (5.42)	91.26 (0.79)	556.84 (2.31)
Hong Kong, SAR	3.76 (0.40)	533.10 (7.36)	33.95 (1.29)	549.10 (3.44)	62.29 (1.43)	545.57 (4.63)
Chinese Taipei	6.06 (0.49)	582.14 (6.17)	36.38 (1.17)	584.46 (2.81)	57.55 (1.36)	559.36 (2.23)
Intern. Avg.	5 (0.1)	466 (1.5)	28 (0.2)	491 (0.9)	67 (0.2)	485 (0.7)

Note. Reported by students; standard errors appear in parentheses.

(h) Teaching Limited by Student Needs

Table 13 summarizes science teaching limited by student needs as reported by teachers in the Southeast Asian TIMSS participating countries. As shown in Table 13, Singapore has the highest average scale scores (10.99) for teaching limited by student needs. This is followed by Thailand (10.01) and Malaysia (9.77). Malaysian teachers' teachings were limited by 'students lacking prerequisite knowledge and skills' ($M = 1.69$), 'uninterested students' ($M = 1.92$), 'disruptive students' ($M = 1.98$), and 'students suffering from lack of basic nutrition' ($M = 2.61$). Thai teachers' teachings were limited by 'students suffering from not enough sleep' ($M = 2.20$) and 'students with mental, emotional, or psychological disabilities' ($M = 2.42$).

Table 13
Descriptive Statistics (Weighted) with Average Scale Scores for Teaching Limited by Student Needs in Southeast Asian Countries (Teachers' Reports)

Statement code	Statement	Southeast Asian countries					
		Malaysia		Singapore		Thailand	
		M	SD	M	SD	M	SD
Teaching limited by student needs (teachers' reports)							
In your view, to what extent do the following limit how you teach this class?							
BTBG15A	Students lacking prerequisite knowledge or skills	1.69	0.60	2.13	0.53	1.84	0.47
BTBG15B	Students suffering from lack of basic nutrition	2.61	0.54	2.85	0.36	2.64	0.51
BTBG15C	Students suffering from not enough sleep	2.24	0.64	2.28	0.59	2.20	0.54
BTBG15D	Disruptive students	1.98	0.61	2.17	0.58	2.11	0.56
BTBG15E	Uninterested students	1.92	0.61	2.12	0.51	1.93	0.48
BTBG15G	Students with mental, emotional, or psychological disabilities	2.79	0.46	2.57	0.52	2.42	0.56
Average scale score		9.77 (0.11)		10.99 (0.09)		10.01 (0.12)	

Note. 1 = A lot, 3 = Not at all [higher average scale score indicates teaching not limited by student needs]; standard errors appear in parentheses.

Table 14 illustrates science teaching limited by student needs as reported by teachers in East Asian countries. As illustrated in Table 14, Japan has the highest average scale scores (12.50) for teaching limited by student needs. This is followed by Hong Kong SAR (10.58), Chinese Taipei (9.95), and Korea (9.78). Korean teachers' teachings were limited by 'disruptive students' ($M = 1.73$), 'uninterested students' ($M = 1.82$), and 'students with mental, emotional, or psychological disabilities' ($M = 2.20$). Taiwanese teachers' teachings were limited by 'students lacking prerequisite knowledge and skills' ($M = 1.89$) and 'students suffering from lack of basic nutrition' ($M = 2.58$). Teachers' teachings were limited by 'students suffering from not enough sleep' ($M = 2.01$) in Hong Kong SAR.

Table 14
Descriptive Statistics (Weighted) with Average Scale Scores for Teaching Limited by Student Needs in East Asian Countries (Teachers' Reports)

Statement code	Statement	East Asian countries							
		Japan		Korea		Hong Kong, SAR		Chinese Taipei	
		M	SD	M	SD	M	SD	M	SD
Teaching limited by student needs (teachers' reports)									
In your view, to what extent do the following limit how you teach this class?									
BTBG15A	Students lacking prerequisite knowledge or skills	2.26	0.63	2.14	0.63	1.99	0.56	1.89	0.62
BTBG15B	Students suffering from lack of basic nutrition	2.99	0.11	2.68	0.51	2.79	0.47	2.58	0.58
BTBG15C	Students suffering from not enough sleep	2.52	0.51	2.04	0.57	2.01	0.60	2.15	0.61
BTBG15D	Disruptive students	2.76	0.44	1.73	0.66	2.34	0.58	2.14	0.73
BTBG15E	Uninterested students	2.42	0.55	1.82	0.59	2.07	0.46	1.83	0.63
BTBG15G	Students with mental, emotional, or psychological disabilities	2.78	0.43	2.20	0.68	2.47	0.59	2.54	0.64
Average scale score		12.50 (0.15)		9.78 (0.17)		10.58 (0.17)		9.95 (0.15)	

Note. 1 = A lot, 3 = Not at all [higher average scale score indicates teaching not limited by student needs]; standard errors appear in parentheses.

Table 15 illustrates science teaching limited by student needs as reported by teachers in Southeast Asian and East Asian TIMSS participating countries. As shown in Table 15, Japan (76.09%) has the highest percentage of students whose teachers' teaching were not limited by student needs with an average science achievement of 575.07. This is followed by Singapore (44.41%) and Hong Kong SAR (38.28%) with average science achievement of 628.95 and 564.94, respectively. On the contrary, Korea (13.52%) has the highest percentage of students whose teachers' teaching were limited by student needs with an average science achievement of 548.22. This is followed by Chinese Taipei (10.17%) and Malaysia (7.54%) with average science achievement of 547.03 and 414.34, respectively.

Table 15
Teaching Limited by Student Needs

Country	Not limited		Somewhat limited		Very limited		Avg. scale score
	Percent of students	Average achievement	Percent of students	Average achievement	Percent of students	Average achievement	
Malaysia	20.10 (2.57)	521.51 (7.05)	72.37 (2.97)	459.76 (5.50)	7.54 (2.08)	414.34 (21.64)	9.77 (0.11)
Singapore	44.41 (2.65)	628.95 (4.07)	54.61 (2.64)	572.24 (5.78)	0.98 (0.50)	504.07 (48.25)	10.99 (0.09)
Thailand	20.86 (3.08)	484.93 (7.96)	73.70 (2.89)	449.99 (5.05)	5.44 (1.79)	423.62 (16.99)	10.01 (0.12)
Japan	76.09 (3.40)	575.07 (2.09)	23.91 (3.40)	558.04 (2.98)	0 (0.00)	~	12.50 (0.15)
Korea	22.13 (3.62)	560.55 (5.22)	64.35 (3.72)	555.28 (2.51)	13.52 (2.53)	548.22 (4.00)	9.78 (0.17)
Hong Kong, SAR	38.28 (5.00)	564.94 (5.46)	57.63 (4.93)	533.15 (5.28)	4.10 (1.73)	530.71 (31.35)	10.58 (0.17)
Chinese Taipei	29.60 (3.45)	592.80 (4.73)	60.23 (3.83)	561.80 (2.73)	10.17 (2.32)	547.03 (7.28)	9.95 (0.15)
Intern. Avg.	28 (0.5)	511 (1.4)	62 (0.5)	480 (0.7)	10 (0.3)	454 (2.2)	

Note. Reported by teachers; standard errors appear in parentheses; ~ insufficient data to report achievement.

(i) Frequency of Student Absences

Table 16 summarizes frequency of student absences as reported by students in Southeast Asian and East Asian TIMSS participating countries. As shown in Table 6, Malaysia (17.54) has the highest percentage of students who absent once a week or more with an average science achievement of 420.04. This is followed by Thailand (9.07%) with an average science achievement of 394.85.

Malaysia also shows the highest percentage of students who absent once every two weeks (11.40%) and once a month (26.46%) with average science achievement of 445.22 and 473.50, respectively. This is followed by Thailand (6.32% and 13.46%) with average science achievement of 420.69 and 435.90, respectively. On the contrary, East Asian countries show lesser frequency of student absences. Korea (96.36%) and Japan (87.19%) have the highest percentage of students who have never or almost never absent with average science achievement of 558.35 and 575.36, respectively.

Table 16
Frequency of Student Absences – Students' Reports

Country	Once a week or more		Once every two weeks		Once a month		Never or almost never	
	Percent of students	Average achievement	Percent of students	Average achievement	Percent of students	Average achievement	Percent of students	Average achievement
Malaysia	17.54 (0.79)	420.04 (5.56)	11.40 (0.56)	445.22 (6.30)	26.46 (0.64)	473.50 (4.77)	44.59 (1.24)	497.76 (4.00)
Singapore	3.03 (0.28)	471.50 (10.00)	2.74 (0.25)	517.70 (8.90)	11.93 (0.50)	568.04 (5.31)	82.31 (0.70)	608.52 (2.75)
Thailand	9.07 (0.64)	394.85 (5.31)	6.32 (0.38)	420.69 (6.12)	13.46 (0.58)	435.90 (5.10)	71.14 (1.04)	470.65 (4.39)
Japan	1.98 (0.21)	511.74 (10.84)	3.07 (0.32)	526.43 (9.19)	7.76 (0.48)	557.81 (3.98)	87.19 (0.60)	575.36 (1.77)
Korea	.47 (0.11)	453.97 (21.11)	0.66 (0.13)	497.87 (20.44)	2.52 (0.24)	486.49 (8.74)	96.36 (0.32)	558.35 (2.22)
Hong Kong, SAR	1.71 (0.28)	450.42 (13.26)	2.36 (0.30)	513.11 (10.60)	9.26 (0.50)	538.40 (4.53)	86.68 (0.80)	549.54 (3.84)
Chinese Taipei	1.62 (0.19)	468.82 (11.47)	1.27 (0.17)	503.37 (15.61)	7.79 (0.45)	550.91 (5.91)	89.32 (0.55)	574.08 (1.90)
Intern. Avg.	61 (0.2)	502 (0.6)	23 (0.1)	477 (0.7)	8 (0.1)	447(1.1)	8 (0.1)	407(1.3)

Note. Reported by students; standard errors appear in parentheses.

Part 2: Interpretation of Data in Response to Research Objective 2

The followings are summaries of some key findings that may be considered for policy recommendations to the Malaysian Ministry of Education to boost Grade 8 students' science performance in the forthcoming TIMSS assessments.:

- i. Malaysia has the second highest total teaching hours per year (1,172.19). However, in terms of the number of hours per year for science teaching, Malaysia has only allocated 193.25 hours (16.49%) for science teaching as compared to TIMSS top performing countries such as Chinese Taipei (18.84%), Japan (18.61%), and Hong Kong SAR (17.13%). Hence, more hours should be allocated for science teaching to ensure higher percentage of students taught the TIMSS science topics.
- ii. TIMSS top performing countries such as Singapore and Chinese Taipei have higher percentages of students taught all science topics, Biology, Chemistry, and Physics as compared to Malaysia (61% for all science topics, 64% for Biology and Chemistry). Singapore has the second highest percentage of students taught all science topics (68%), the second highest percentage for Biology (69%), third highest for Chemistry (78%), and the highest percentage of students taught the TIMSS Physics topics (85%). Chinese Taipei has the third highest percentage of students taught all science topics, the highest percentage for Biology (89%), and Chemistry (89%). Hence, a science curriculum revamp and/or integration of TIMSS science topics should be considered to ensure higher percentage of Malaysian eighth grade students taught the TIMSS science topics to better prepare them for the forthcoming TIMSS assessments.

- iii. Generally, Malaysia has the highest average scale score of 10.38, followed by Hong Kong SAR (10.13), Thailand (10.12), Japan (9.88), Korea (9.35), Singapore (9.00), and Chinese Taipei (8.93) in emphasizing science investigation. Ironically, Singapore has the lowest percentage of students (7.65) in which teachers emphasize science investigation about half the lesson or more, with the highest average achievement of 617.24. Singapore also has the highest percentage of students (92.35) in which teachers emphasize science investigation less than half the lesson, with the highest average achievement 594.94. The emphasis of science investigation in Malaysian secondary schools should not merely focus on basic/integrated scientific skills but also needs to highlight open-ended contextual problem-solving activities or problem-based learning that enhance higher order thinking skills.
- iv. Malaysia has reported 98.70% of students attended schools with science laboratories and 88.78% of students whose teachers have assistance available when students are conducting experiments with average science achievement of 471.32 and 472.19, respectively. In contrast, Singapore and Hong Kong SAR (with average science achievement of 596.98 and 544.81, respectively) have reported 100% of students attended schools with science laboratories. This is followed by Japan (99.43%) and Korea (99.14%) with average science achievement of 571.04 and 555.68, respectively. Hong Kong SAR (98.37%) and Singapore (98.22%) have the highest percentage of students whose teachers have assistance available when students are conducting experiments. Eighth grade students' average science achievement were reported as 544.42 and 597.36, respectively. Resources for conducting science experiments (science laboratories and assistance available) should be equally and adequately distributed to all Malaysian schools to enhance science learning.
- v. Malaysia (90.39%) has the highest percentage of students who responded 'No' on the availability of computer for them to use during science lessons with an average science achievement of 466.70. On the contrary, Japan (55.45%) and Singapore (51.83%) have the highest percentage of students with computer availability in science lessons. Eighth grade students' average science achievement were reported as 571.37 and 592.04, respectively. The use of computers should be made available in Malaysian secondary schools. Based on literatures, the importance of computers in science learning is undeniable.
- vi. Malaysia has the lowest percentage of students whose teachers have them use computers at least monthly 'to practice skills and procedures' (5%), 'to look up for ideas and information' (9%), 'to do scientific procedures and experiments' (3%), 'to study natural phenomena through simulations' (7%), and 'to process and analyze data' (4%). On the contrary, Singapore has the second highest percentage of students whose teachers have them use computers at least monthly 'to practice skills and procedures' (31%), 'to look up for ideas and information' (41%), 'to do scientific procedures and experiments' (27%), 'to study natural phenomena through simulations' (34%), and 'to process and analyze data' (27%). The allocated time for science teachings in Malaysian schools should encourage and integrate the use of computer to further support science learning. However, this is only possible with computer availability for science lessons.
- vii. Singapore has the highest percentage of students who use Internet to 'access assignments posted online by the teacher' (90.10%) and 'communicate with the teacher' (49.37%) as compared to 27.31% and 45.20% for Malaysian eighth grade students, respectively. Hence, the use of Internet for schoolwork should be encouraged among Malaysian students especially for them to access assignments

posted online by their teachers and to communicate with their teachers. However, this is only possible with a satisfying Internet connectivity and accessibility.

- viii. Malaysia (11.28%) has the second highest percentage of students who spent three hours or more on assigned science homework with an average science achievement of 468.20. Ironically, on the contrary, East Asian countries eighth grade students spent less weekly time on assigned science homework. 91.26% of the Korean students and 84.21% of the Japanese students spent 45 minutes or less on assigned science homework with average science achievement of 556.84 and 576.36, respectively. Instead of assigning plenty of science homework to Malaysian students, perhaps, the quality and type of science homework assigned to the students should be re-examined as an effort to boost Malaysian students' science achievement via science homework.
- ix. Malaysia has the lowest average scale scores (9.77) for teaching limited by student needs as compared to Singapore, Japan, and Hong Kong SAR. Malaysian teachers' teachings were limited by 'students lacking prerequisite knowledge and skills' ($M = 1.69$), 'uninterested students' ($M = 1.92$), 'disruptive students' ($M = 1.98$), and 'students suffering from lack of basic nutrition' ($M = 2.61$). Malaysian science teachers should be given training on psychology, communication and/or counselling skills so to ensure all psycho-social factors that affect science learning are taken care of. Perhaps, in the era of new normal, student-teacher interaction should be more frequent and enhanced through social learning platforms.
- x. Malaysia (17.54) has the highest percentage of students who absent once a week or more with an average science achievement of 420.04. Malaysia also shows the highest percentage of students who absent once every two weeks (11.40%) and once a month (26.46%) with average science achievement of 445.22 and 473.50, respectively. On the contrary, East Asian countries show lesser frequency of student absences. Korea (96.36%) and Japan (87.19%) have the highest percentage of students who have never or almost never absent with average science achievement of 558.35 and 575.36, respectively. Intentional efforts should be made by the Malaysian school management boards, Parent Teacher Association (PTAs) and schoolteachers to ensure students are interested and motivated to attend science classes.

Conclusions

Summary and Implications

This study provides a comprehensive overview on the correlates of science classroom teachings with science achievement in TIMSS, not only on the common aspects of classroom instructions (i.e., teaching time spent on science, science topics taught, emphasis of science investigation, resources for conducting science experiments, computer activities during science lessons, use of Internet for schoolwork, weekly time spent on science homework) but also related to psycho-sociological factors (e.g., teaching limited by student needs, and student absences) that affect eighth graders' science achievement in TIMSS. This study also revealed one very important factor that was found to be crucial to enhance science achievement possibly supported by technology, i.e., teacher-student interaction. Due to large class size and lack of integration in pedagogical content knowledge and resources available, traditional lecture-based teacher-centered approaches were quite commonly found in the classroom activities of Malaysian schools. The implication is that more in-service training programs need to be conducted to introduce interactive teaching and learning pedagogies through blended learning platforms.

Significance and Future Direction

In addition, with comparison made not only among three Southeast Asian countries but also with four East Asian countries (out of which including countries with top achievement in TIMSS), better interpretation of data can be made with conclusion drawn though not explicitly stated. It is expected that this study could make significant contribution with suggestions of policy recommendations to the Ministry of Education to boost Malaysian Grade 8 students' science performance in the forthcoming TIMSS assessments.

For example, the crucial factor found to be contributing much to the students' science achievement in high performing country such as Singapore, that is student-teacher interaction should be more frequently conducted. Although there is a big class size in Malaysian schools that are scattered in wider geographical areas as compared to Singapore, students' interaction could be enhanced through digital tools as well as blended-mode social learning platforms available, e.g., Edmodo, Google Classroom, Facebook, Telegram, Zoom, to name a few. Efforts should also be made to ensure students are not absent from class, are interested and motivated to science learning. The Ministry of Education should also ensure higher percentage of students taught the TIMSS science topics with integrated approaches that enhance higher thinking skills supported by digital tools and e-platforms, e.g., Project-based Activities (PBA), Problem-based Learning (PBL), Inquiry-based Science Education (IBSE), to name a few.

Based on the discussions made in response to Research Question 2, more actions should be taken by the Ministry of Education to ensure that the hours allocated for science teaching should include the integration of use of computer and Internet to support learning. Resources for conducting science experiments should be equally and adequately distributed. In the new normal, there is also possibility to demonstrate and facilitate the conduct of online science experiment, e.g., through YouTube or Tik Tok to ensure reach out to wider audience, hence the problem to ensure equal distribution could be solved.

Declaration of Interest

Authors declare no competing interest.

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