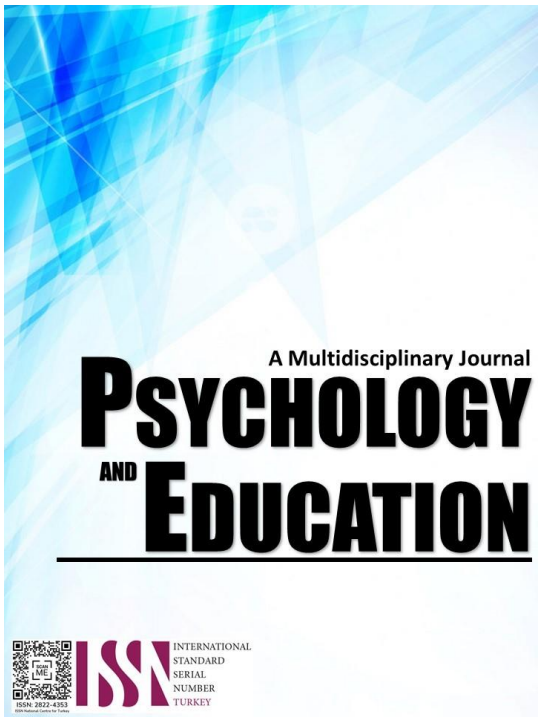
PREDICTORS OF STUDENT'S PERFORMANCE IN TIMSS MATHEMATICS RELEASED ITEMS



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Research Article

Predictors of Student's Performance in TIMSS Mathematics Released Items

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Abstract

The Philippines scored 297 in Mathematics and 249 in Science in the 2019 Trends in International Mathematics and Science Study (TIMSS), the lowest among 58 participating countries. The study's findings open the door to determining various factors that can help alleviate the students' alarming performance. As a result, this study is a quantitative study that aimed to determine student performance in TIMSS Mathematics released items and predictors using the selected profile variables. The study included 49 high school students in total. Regression analysis was used to determine whether there are any significant variables that influence the assessment's outcome. The study's main tool was the 2011 TIMSS Mathematics released items. The findings revealed that significant predictors include grade 7 math average, home computer availability, and gender. The study can be used as a guide to determine students' strengths and weaknesses in TIMSS released items.

Keywords: *mathematics, performance, predictors, and TIMSS released items.*

Introduction

Science and mathematics education has long been recognized as an important factor in development, prompting nations to prioritize it on their national agendas. How students learn and how to assess student performance in these areas is thus a top priority for policymakers and educators around the world. The Trends in Mathematics and Science Study (TIMSS), which has been conducted since 1995 and every four years since then by the International Association for the Evaluation of Educational Achievement (IEA), is one study that measures student performance in Science and Mathematics and is gaining increasing attention (Ogena, Laña, & Sasota, 2010).

Since 1995, TIMSS has reported on international trends in fourth and eighth grade mathematics and science achievement. The sixth assessment, TIMSS 2015, resulted in a 20-year trend line. Because TIMSS tracks changes in achievement at regular intervals, it is an excellent tool for investigating how new or revised educational policies affect achievement. TIMSS 2011 was attended by 63 countries.

The TIMSS Mathematics and Science assessments are based on comprehensive assessment frameworks created in collaboration with participating countries. The frameworks specify the knowledge, skills, and understandings to be assessed in some detail.

TIMSS measures overall Math and Science achievement. Furthermore, results are presented in accordance with four International Benchmarks (advanced, high, medium, and low) as well as major content domains (for example, algebra, geometry, and biology). Countries also receive item-by-item results for approximately 200 items per subject per grade for diagnostic purposes (e.g., fourth-grade mathematics, eighth-grade science). One of the primary goals of TIMSS is to provide important background information that can be used to improve mathematics and science teaching and learning. TIMSS, for example, collects extensive data on curriculum and curriculum implementation, instructional practices, and school resources (TIMSS, 2015).

The TIMSS Mathematics assessment is divided into two parts: (1) a content dimension that specifies the subject matter to be assessed and (2) a cognitive dimension that specifies the cognitive or thinking processes to be assessed. TIMSS assesses student knowledge in three content domains in fourth grade: number, geometric shapes and measures, and data display. TIMSS assesses student knowledge in four content domains in grade 8: numbers, algebra, geometry, and data and chance. TIMSS assesses students' mathematical thinking in three cognitive domains at both grades (and across all content domains): knowing, applying, and reasoning. (Martin, Mullis, & Hooper, 2016).

The TIMSS 2019 Mathematics Assessment Devoted to Content and Cognitive Domains at Eighth Grade is presented in the table below. This is, in essence, the intended curriculum. It also describes the TIMSS-Mathematics standards.

Table 1. *Target Percentages of the TIMSS 2019 Mathematics Assessment Devoted to Content and Cognitive Domains at Eighth Grade*

Content domains	*Percentages*
Number	30%
Algebra	30%
Geometry	20%
Data and Chance	20%
Cognitive Domains	*Percentages*
Knowing	35%
Applying	40%
Reasoning	25%

Source: Mullis, I. V. S., & Martin, M. O. (Eds.). (2017). TIMSS 2019 Assessment Frameworks.

Figure 1 above relates to the DO 29 s .2017- Policy Guidelines on System Assessment in the K to 12 Basic Education Program and DO 55 S.2016-Policy Guidelines on the National Assessment of Student Learning for the K to 12 Basic Education Program. This implies that, despite performing poorly in TIMSS and PISA, the Department of Education has taken steps to develop students' assessment skills.

Research Questions

The study aimed to determine the predictors of students' performance in TIMSS Mathematics released items. Specifically, it sought to answer the following questions:

1. What is the performance of grade 8 and 9 students in TIMSS Mathematics released items according to the following:
   1.1 content domains (Number, Algebra, Geometry, and Data and Chance),
   1.2 cognitive domains (Knowing, Applying, and Reasoning), and
   1.3 proficiency level (Advanced, High, Intermediate, and Low)?
2. Is there a linear combination that can predict students' performance in TIMSS Mathematics Released Items?

Literature Review

Performance of students in TIMSS in the Philippines

The following literature was cited to describe the performance of Filipino students, particularly in TIMSS, which served as the gaps that required the current study to be conducted in the hopes of opening the door to improving student performance in national and international assessments.

In the 1999 TIMSS, which included second-year high school students, the Philippines finished 36th in both Math and Science out of the 38 countries that took part in the assessment test. In the 2003 TIMSS, the Philippines ranked 41st out of 45 countries in both Math and Science (43rd of 46 countries). We took part in the TIMSS in 2008 and finished last out of ten countries in both Advanced Math and Science. We are not unfamiliar with finishing last or near the bottom of international large-scale assessments. These results must have been the reason for the country's decision to withdraw from TIMSS. It took a bit of time to rejoin TIMSS and other international assessments with a clear policy directive issued early on by the current Department of Education (DepEd). That was a bold move that deserves to be recognized for stating that education quality is the most serious problem that has plagued the system for decades (Raya, 2021).

We feasted on the results, which came one after the other, beginning with PISA. While some looked beneath the surface to understand the results, others mocked the system for producing the "mythical 80% poor learners." Despite all of the criticism for our students' poor performance, the DepEd has remained unfazed. Participating in international large-scale assessments can supplement our own national assessments and help us place our students against established global benchmarks. The anticipated (poor) results guide and compel us to implement the reforms. Looking at TIMSS 1999 and PISA 2018, two decades apart, we see that the problem of achieving quality education is chronic and will not be solved overnight (Raya, 2021).

Despite the good intentions and efforts of successive DepEd secretaries since 1999, education quality must have remained stagnant over time. Pointing fingers at anyone is counterproductive. The DepEd would prefer to have all hands on deck to work out solutions collectively. It has, in fact, invited a wide range of stakeholders to examine its reform agenda aimed at improving teacher quality, improving the learning environment, reviewing the K-12 curriculum, and encouraging stakeholder collaboration. These are good points to expand on or even hammer home (Raya, 2021).

Asian countries dominate the top half of the 76 countries ranked. European countries occupy the majority of the positions fifth through 30th in the ranking, with the United States near the bottom of the third, tied for 28th with Italy. The bottom half of the rankings is dominated by African and Latin American nations. Singapore is the world's smartest country,

with Hong Kong, South Korea, Taiwan, Japan, Finland, Estonia, Switzerland, the Netherlands, and Canada rounding out the top ten. (Speiser, 2015 cited by Magas, 2020).

Over the years, ASEAN countries have dominated other countries in the field of mathematics. The Philippines, on the other hand, is an exception. Filipino grade-8 students only participated in the TIMSS in 1995, 1999, 2003, and 2007, according to the IEA-TIMSS website. When the TIMSS was first administered in 1995 to 42 countries, the Philippines finished 30th in Mathematics. (Ramos et al, 2015 cited by Gammad, Madrid, & Magas, 2017).

In 1999, the Philippines finished 36th out of 38 participating countries, with 345 points for Mathematics and Singapore with 604 points. Morocco (337 points) and South Africa (337 points) were the two lowest-scoring countries (with 275). The Philippines ranked 41st out of 45 countries in 2003, with 378 points, 33 points higher than the result in 1999. (Gabriel, 2012, cited by Magas, 2020).

Table 2. *Top 10 Countries in International Association for the Evaluation Achievement (IEA), Trends in International Mathematics and Science Study (TIMSS)*

TIMSS 1995	*TIMSS 1999*	*TIMSS 2003*	*TIMSS 2007*	*TIMSS 2011*
1.Singapore	1.Singapore	1.Singapore	1.Taiwan	1.South Korea
2.South Korea	2. South Korea	2. South Korea	2. South Korea	2. Singapore
3. Japan	3. Taiwan	3. Hong Kong	3. Singapore	3. Taiwan
4.Hong Kong	4. Hong Kong	4. Taiwan	4. Hong Kong	4. Hong Kong
5. Flanders (Belgium)	5. Japan	5. Japan	5. Japan	5. Japan
6. Czech Republic	6. Flanders (Belgium)	6. Flanders (Belgium)	6. Hungary	6. Russia
7. Slovakia	7. Netherlands	7. Netherlands	7. England and Wales	7. Israel
8. Switzerland	8. Slovakia	8. Estonia	8.Russia	8. Finland
9. Netherlands	9. Hungary	9. Hungary	9. United States	9. United States
10. Slovenia	10.Canada	10.Malaysia	10.Lithuania	10.England and Wales

Source: Gammad, Madrid, and Magas (2017)

Table 3. *Rank of the Philippines in the Trends in International Mathematics and Science Study (TIMSS) 1995, 1999, 2003, and 2008*

Philippine Average TIMSS Score (Grade 8)				
Indices	1995 Results	1999 Results	2003 Results	2008 Results
Score	-	345	378	355
International Average	345	489	466	500
Rank	30	36	41	10
Number of participating Countries	42	38	45	10

Source: Gammad, Madrid, and Magas (2017)

Filipinos fared worst among 58 countries in an assessment for mathematics and science for Grade 4 students, according to a study by a Netherlands-Based Research Institution as cited by Bernardo (2020).

The Philippines scored 297 in Mathematics and 249 in Science, according to the trends in International Mathematics and Science Study (TIMSS) 2019 by the International Association for the Evaluation of Educational Achievement (IEA). Both scores are lower than how the country fared in 2003, which are 358 in math and 332 in science, based on the study. Meanwhile, neighbouring country Singapore topped both assessments, getting a score of 625 in Mathematics and 595 in Science. The TIMSS makes use of a 4-level scale to interpret students' scores: Advanced International Benchmark (625), High International Benchmark (550), Intermediate International Benchmark (475), and Low International Benchmark (400).

Only 1% of Filipino students met the high standard in math. In other words, students use conceptual understanding to solve problems. They can solve two-step word problems using their conceptual understanding of whole numbers. They demonstrate an understanding of the number line, multiples, factors, rounding numbers, and fraction and decimal operations. Students can solve simple measurement problems. They demonstrate an understanding of shape and angle geometric properties. Students can interpret and apply data from tables and graphs to solve problems. Six percent of Filipino students scored in the intermediate range, indicating that they can apply fundamental mathematical knowledge in simple situations. Meanwhile, 19% of Filipino students scored low, indicating that they have some basic mathematical knowledge. They can add, subtract, multiply, and divide whole numbers with one and two digits. They are able to solve simple word problems. They understand simple fractions and common geometric shapes. Simple bar graphs and tables can be read and completed by students. (TIMSS, 2019, cited by Bernardo, 2020).

The 2019 edition was held in 64 countries in the fourth and eighth grades, but the Philippines only participated in the fourth-grade assessment. In some ways, the results are unsurprising, given that the Philippines has consistently performed poorly in mathematics in global assessments. It had not been able to move out of the bottom five rankings since joining the Trends in Mathematics and Science Study TIMSS (Mullis et al., 2004).

With the aforementioned information regarding

students' poor performance, particularly in Mathematics, it is critical to review the curriculum and make necessary revisions to alleviate the students' alarming performance in TIMSS and other international studies such as PISA, among others. The study will be conducted to determine the predictors of students' performance in the discipline in order to help improve the quality of mathematics education in the Philippines. The variables in the study were chosen based on the literature and the recommendations of an education expert.

Furthermore, because it represents the teaching, learning, and leading standards in the setting of the study's chosen basic education institution, the study will serve as a benchmark. Furthermore, it will pave the way for the improvement and harmonization of the curriculum, learning competencies, and Trends in International Mathematics and Science Study content. Despite the fact that extensive studies have been conducted to investigate the various problems and challenges in the Philippine education system, it is still very useful to identify the likely predictors that may assist students in becoming more proficient in Mathematics.

Methodology

The predictive method was used in this study to see if there is a linear combination that can predict student performance in TIMSS Mathematics Released Items.

Participants/Respondents

The study was conducted in Cauayan City, Philippines. A total of 49 selected high school participated in the study.

Instruments of the Study

The 2011 TIMSS Mathematics Released Items was adopted to assess the proficiency of the students in the discipline. With regards to the selection of items included in the examination, mapping of the items in 2011 TIMSS released items and the Most Essential Learning Competencies (MELCS) was made. Moreover, only 60 items were selected so that the students can answer all the items completely since they were only given one hour to answer. The table below shows the Mathematics Assessment Devoted to Content and Cognitive Domains of the test which was based on the percentages of 2019 TIMSS-content and cognitive domains.

Table 4.

Content Domains	*Number of items*	*Percentage*
Numbers	18	30%
Algebra	18	30%
Geometry	12	20%
Data and Chance	12	20%
Total	60	100%
Cognitive Domains	*Number of items*	*Percentages*
Knowing	21	35%
Applying	24	40%
Reasoning	15	25%
Total	60	100%

Procedure

The researcher was guided by the following procedures:

1. Asked for approval from the school heads to conduct this study.
2. The Mathematics teachers were asked to conduct the test and questionnaire among the respondents to gather necessary information.
3. After collecting all the data, it was tallied, analyzed, and interpreted.

Results and Discussion

This section presents the findings in relation to the research questions of the study. Multiple Linear Regression was used to identify the significant variables that can predict student performance in TIMSS Mathematics Released Items.

Table 5. *Performance of the respondents in TIMSS Released Items According to Content Domains*

Content Domains	*Level*	*Frequency*	*Percent*
Numbers	Low	-	-
	intermediate	14	28.57
	High	15	30.61
	Advanced	20	59.18
Algebra	Low	8	16.33
	intermediate	14	28.57
	High	19	38.78
	Advanced	8	16.32
Geometry	Low	11	22.45
	intermediate	23	46.94
	High	5	10.20
	Advanced	10	20.41
Data and Chance	Low	5	10.20
	intermediate	23	46.94
	High	14	28.57
	Advanced	7	14.29

The performance of the respondents in relation to the content domains included in the TIMSS released items was determined using frequency count and percentage. In terms of numbers, the majority of respondents achieved the advanced level, indicating that they performed better in that specific content domain. When it comes to Algebra, the majority of students received high scores. The majority of students in Geometry were intermediate level, and intermediate level scores dominated in Data and Chance. Students perform better in algebra in terms of high benchmark, indicating that they are better at representing problems using mathematical expressions. When it comes to Geometry, however, only 10.20% of students met that standard. This implies that students did not perform well when dealing with object shapes, sizes, angles, and dimensions. Although the geometry result is not favorable when the high benchmark is considered, it should be noted that the number of students who reached the intermediate benchmark is greater than the number of students in numbers and algebra, and the same is true for data and chance. That is, those students meet the minimum level because the intermediate benchmark is the average level that the students should achieve. Nonetheless, respondents in this study performed significantly better than students in the Philippines in the most recent TIMSS results.

Table 6. *Performance of the respondents in TIMSS Released Items According to Cognitive Domains*

Cognitive Domains	*Level*	*Frequency*	*Percent*
Knowing	Low	2	4.08
	intermediate	13	26.53
	High	20	40.82
	Advanced	14	28.57
Applying	Low	4	8.16
	intermediate	19	38.78
	High	17	34.69
	Advanced	9	18.37
Reasoning	Low	3	6.12
	intermediate	27	55.10
	High	13	26.53
	Advanced	6	12.25

The Table 6 shows the level, frequency, and percent distribution of the respondents in terms of cognitive domains. The Trends in International Mathematics and Science Study (TIMSS) includes three cognitive domains namely knowing, applying, and reasoning. In this study, 40.82% of the students reached the high benchmark which is the dominant while 28.57% reached the advanced benchmark in terms of knowing. Meanwhile, for applying, 38.78% of the students finished intermediate benchmark which is the dominant, 34.69% attained High benchmark, and 18.37% reached advanced benchmark. When it comes to Reasoning, more than half (55.10%) of the students reached the intermediate benchmark, 26.53% reached high benchmark, and only 12.25% attained advanced benchmark. Although the outcome is encouraging, there is still much work to be done because only a few students have reached advanced benchmarks, particularly in applying and reasoning. Because mathematics places a greater emphasis on developing students' applying and reasoning skills, it should be the primary goal of all Mathematics teachers in the country to assist students in improving their performance, particularly in national and international assessments.

Table 7. *Performance of the respondents in TIMSS Released Items According to Proficiency level/International Benchmarks*

Proficiency level	*Frequency*	*Percent*
Low	-	-
Intermediate	15	30.61
High	24	48.98
Advanced	10	20.41

According to table 7, the number of students who have reached the high benchmark outnumber those who have reached the intermediate benchmark.

Furthermore, 20.41% of students have achieved the advanced level. In the 2019 TIMSS results, only 1% of Filipino students met the high benchmark, 6% met the intermediate benchmark, and 19% met the low benchmark in Mathematics. Despite the fact that the study was conducted at the high school level and the Philippines only participated in the 2019 TIMSS elementary level, the results show that there is some improvement in student performance in the discipline. The country last participated in TIMSS in 2008, with elite students from Philippine Science High School and some private schools taking part. The Philippines finished last among participating countries in the 2008 TIMSS.

Table 8. *Means, Standard Deviations, and Inter Correlations for Performance in TIMSS Released Items and Predictor Variables*

	M	*SD*	*1*	*2*	*3*
Performance	34.31	11.83	.435**	-.025	.356**
1	89.86	4.43		.545**	.161
2	.97	.17			.253
3	1.69	.47			

Table 8 displays the mean, standard deviation, and intercorrelations for TIMSS Released Items and predictor performance. Predictor variables include grade 7 math average, home computer and internet availability, and gender. The grade 7 average in mathematics (.435**) and sex (.356**) was positively correlated with performance. It implies that the higher the average in grade 7 mathematics and, if female, the better the performance in TIMSS released items. According to Maslang (2022), the students' previous average is the best predictor of their current performance. Furthermore, the gender result (coded 1-male, 2-female) is supported by a UNESCO report that the Philippines is one of three Southeast Asian countries where girls outperform boys in Mathematics.

Table 9. *Stepwise Multiple Regression Analysis Summary for Grade 7 average in Math, Availability of computers and internet, and Sex in Predicting Performance in TIMSS Released Items.*

	Unstandardized coefficients B	*E*	*SC*	*T*	*Sig.*	*Collinearity Statistics*	
						T	*VIF*
C	-105.549	33.974		-3.106	.004		
1	1.740	.429	.651	4.056	.000	.703	1.423
2	-33.130	11.459	-.473	-2.891	.007	.675	1.481
3	9.319	3.494	.371	2.667	.012	.935	1.069

Multiple regression, specifically stepwise regression, was used to determine the best linear combination of grade 7 math average, availability of computers and internet at home, and sex for predicting student performance in TIMSS Released Items. However, prior to performing stepwise regression, assumptions such as normality and collinearity were verified. The Kolmogorov-Smirnov value is not statistically significant for normality, indicating that the data were normally distributed. The means, standard deviations, and intercorrelations can be found in Table 5. This combination of variables significantly predicted students' performance in TIMSS-released items, $F(3,31) = 8.080$, $p<0.001$, with all three variables significantly contributing to the prediction. The adjusted *R-squared* value was .385. This implies that 38.5% of the variance in students' performance was explained by the model. According to Cohen (1988), it is a large effect.

Conclusion

Based from the result of the study, the following conclusions are drawn: (1) Numbers outperformed Algebra, Geometry, Data, and Chance in terms of content domain performance. However, a greater number of students achieved low benchmarks in Geometry, indicating that they need to improve when dealing with sizes, shapes, positions, angles, and dimensions of things, among other things. (2) In terms of cognitive domains, students performed better for items under knowing than for items under applying and reasoning. (3) In terms of proficiency level, none of the students met the low standard, while the majority met the high benchmark. (4) The predictors of student's performance in TIMSS released items include grade 7 average in mathematics, availability of computers at home, and sex. The study can be used as a guide for determining the strengths and weaknesses of students in TIMSS released items.

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