TIMSS -R
MATHEMATICS ACHIEVEMENT OF EIGHTH GRADERS FROM SOUTH EAST ASIAN COUNTRIES

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In 1999, the Third International Mathematics and Science Study (TIMSS) was replicated at the eighth grade. This study known as TIMSS–R or TIMSS-1999 was designed to provide trends in eighth grade mathematics and science achievement in an international context. This paper reviews the mathematics achievement of Eighth graders from five South East Asian countries (Indonesia, Malaysia, Philippines, Singapore and Thailand) that participated in TIMSS-1999. The achievement data show significant differences amongst eighth graders from South East Asia. The paper also reviews the intended mathematics curriculum of these countries and attempts to explore factors that may have contributed towards high achievement.

WHAT IS TIMSS-R?

The Third International Mathematics and Science Study, TIMSS, (Beaton, Mullis, Martin, Gonzalez, Kelly, & Smith, 1996) was conducted in 1995. Forty-one countries participated and testing was carried out at five grade levels. The aim of TIMSS, also known as TIMSS-1995, was to provide a base from which policy makers, curriculum specialists and researchers could better understand the performance of their educational systems. The two South East Asian countries that participated in TIMSS were Singapore and Thailand.

In 1999, TIMSS was replicated at the eighth grade. This study known as TIMSS–R or TIMSS-1999 (Mullis, Martin, Gonzalez, Gregory, Garden, O'Conner, Chrostowski, & Smith, 2000) was designed to provide trends in eighth grade mathematics and science achievement in an international context. Thirty-eighth countries including Indonesia, Malaysia, Philippines,

Singapore and Thailand participated in TIMSS-99. As Singapore and Thailand were the only two South East Asian countries that participated in both TIMSS and TIMSS-1999, this paper only discusses data related to TIMSS-1999 for the five South East Asian Countries: Indonesia, Malaysia, Philippines, Singapore and Thailand.

THE PARTICIPANTS

Table 1 gives some background data about the students from South East Asia (SEA) who participated in TIMSS-1999. In all the countries, except for Singapore, 150 schools participated in the study. In Singapore 145 schools participated in the study. The number of students (eighth graders) who took the tests varied from country to country as this was determined by the sampling requirements. The number of students ranged from 4966 to 6601. In all the countries with the exception of Philippines, students were in their eighth year of formal schooling. In the Philippines, the students were in their seventh year of formal schooling. The average age of the students from SEA ranged from 14.1 to 14.6 years.

Table 1
Background data of the students from SEA in TIMSS-1999

Country	Number of Schools	Number of Students	Number of years of formal schooling	Average age of students (years)
Indonesia	150	5848	8	14.6
Malaysia	150	5577	8	14.4
Philippines	150	6601	7	14.1
Singapore	145	4966	8	14.4
Thailand	150	5732	8	14.5

THE TESTS

The TIMSS–1999 tests (Research & Evaluation Branch, MOE; 2000) included more than 300 multiple-choice and open-ended test items, covering a range of mathematics and science topics and skills. About one-third of these items were identical to those in TIMSS –1995. Eighth different booklets containing a selection of the 162 mathematics and 146 science items were administered to the sampled students. Each student completed the test in one booklet. Testing time was 90 minutes. In accordance with IEA policy (TIMSS, 2000),

about one-half of the TIMSS-1999 items was not released to the public but kept secure for future use to measure international trends in mathematics and science achievement. Eighty-two of the mathematics items used in TIMSS-1999 were released. The mathematics items were classified by content category and performance expectation.

CONTENT CATEGORY

The mathematics items were reported according to five content areas (Mullis, et al., 2000). These areas, with their main topics were:

- Fractions and number sense

  Includes whole numbers, fractions and decimals, integers, exponents, estimation and approximation, proportionality;
- Measurement

  Includes standard and non-standard units, common measures, perimeter, area, volume, estimation of measures;
- Data representation, analysis, and probability

  Includes representing and interpreting tables, charts, and graphs; range, mean; likelihood, simple numerical probability;
- Geometry

  Includes points, lines, planes, angles, visualization, triangles, polygons, circles, transformations, symmetry, congruence, similarity, and constructions; and
- Algebra

  Includes number patterns, representation of numerical situations, solving of linear equations, operations with expressions, representations of relations and functions.

Table 2, shows the distribution of the test items by content area and type. A total of 162 items were used in TIMSS-1999 and 82 of these items are released. Almost 40 % of the items were in the content area Fractions and number sense. About 20 % of the items were in the content area Algebra, 15 % in the content area Measurement, and 13 % each in the content areas Geometry and Data representation, analysis and probability. The Majority of the items (i.e. 77 %) were multiple choice in type. Only about a quarter of the items had short answers (13 %) and extended responses (10 %).

Table 2
Distribution of the test items by content area and type

Content Area	Type of Item Number of items	Multiple Choice (MC)	Short Answer (SA)	Extended Response (ER)
Fractions & number sense	61 (35)	47 (27)	11(6)	3(2)
Measurement	24 (8)	15 (7)	4 (1)	5 (0)
Data representation, analysis, & probability	21(10)	19 (8)	1 (1)	1 (1)
Geometry	21 (9)	20 (9)	1 (0)	0 (0)
Algebra	35 (20)	24 (14)	4 (2)	7 (4)
Total	162 (82)	125 (65)	21 (10)	16 (7)

The numbers within the ( ) give the number of items released

PERFORMANCE EXPECTATION

The mathematics items were classified into the following performance expectations:

Knowing (K).

Using Routine Procedures (URP).

Using Complex Procedures (UCP).

Investigating & Problem Solving (I and SP).

Mathematical Reasoning & Communicating (MR and C).

Table 3 shows the distribution of the 82 released items by content area and performance expectation. About a third (31.7 % to be exact) of these items belonged to the Investigating and Problem Solving category which may be considered a high level of mathematical performance i.e. applying mathematical knowledge to solve problems while almost a quarter (25.6 % to be exact) of them belonged to the Knowing category which may be considered the lowest level of mathematical performance, i.e. mere recall of mathematical facts and knowledge. About 40 % of these items belonged

to the Using Routine Procedures (18.3 % to be exact) and Using Complex Procedures (22 % to be exact) categories. These items mainly tested mathematical skills in simple and complex situations. Only a very small percentage (2.4 % to be exact) of the items released belonged to the category Mathematical Reasoning and Communication that may be considered as the highest level of mathematical performance tested in the TIMSS 1999 tests.

Table 3
Distribution of released test items by content area and performance expectation

Content Area	Performance Expectation					Total
	K	URP	UCP	I & SP	MR & C	
Fractions & number sense	7	7	9	12	0	35
Measurement	3	0	1	4	0	8
Data representation, analysis, & probability	1	0	6	2	1	10
Geometry	2	3	2	2	0	9
Algebra	8	5	0	6	1	20
Total	21	15	18	26	2	82

MATHEMATICS ACHIEVEMENT OF EIGHTH GRADERS FROM SOUTH EAST ASIA

Thirty-eight countries participated in TIMSS-1999. The countries ranked in order of achievement were Singapore, Republic of Korea, Chinese Taipei, Hong Kong SAR, Japan, Belgium (Flemish), Netherlands, Slovak Republic, Hungary, Canada, Slovenia, Russian Federation, Australia, Finland, Czech Republic, Malaysia, Bulgaria, Latvia (LSS), United States, England, New Zealand, Lithuania, Italy, Cyprus, Romania, Moldova, Thailand, Israel, Tunisia, Republic of Macedonia, Turkey, Jordan, Islamic Republic of Iran, Indonesia, Chile, Philippines, Morocco and South Africa. Table 4 shows the ranking and average scale scores of the South East Asian countries that participated in TIMSS-1999. Singapore and Malaysia had average scale scores above the International average while Thailand, Indonesia and the

Philippines had average scores below the International average. In TIMSS-1995 (Beaton et al., 1996), Singapore was also ranked top for the achievement for the eighth graders. The mean score was 643 for Singapore. Thailand failed to meet the approved sampling procedures at classroom level for TIMSS-1995 and was not ranked but the mean score of their eighth graders was 522.

From Table 4 it is obvious that the performance of students from Singapore was significantly better than that of students from the other South East Asian countries. The performance of the students from Malaysia was also commendable as their average scale scores were significantly higher than the international average. It is also worthy to note that the average scale scores of the other three countries, Thailand, Indonesia and the Philippines were significantly lower than the International average.

Table 4
Rank and Average Scale Scores of Eighth Graders from SEA

Country	Rank	Average Scale Score
Singapore	1	604 (6.3)
Malaysia	16	519 (4.4)
International Average	-	*487 (0.7)*
Thailand	27	467 (5.1)
Indonesia	34	403 (4.9)
Philippines	36	345 (6.0)

Numbers within ( ) give the standard errors

AVERAGE ACHIEVEMENT ACROSS MATHEMATICS CONTENT AREAS

As the TIMSS-1999 tests covered five content areas in mathematics, Tables 5A and 5B show the average achievement of participants from SEA in the mathematics content areas. From Tables 5A and 5B, it is evident that performance in the five content areas for all countries was consistent with their overall performance in the tests. However, focusing on the relative performance of individual countries across the five content areas, certain

trends are evident. Singapore's eighth graders performed best on items in the content area Fractions and number sense, followed by Measurement, Algebra, Data representation, analysis and probability; and Geometry in decreasing order of performance. Malaysia's eighth graders also performed best on items in the content area Fractions and number sense followed by Measurement and Algebra like Singapore students. However their weakest content area was Data representation, analysis and probability Thailand's and Indonesia's eighth graders performed best on items in the content area Geometry but differed in their relative performance for the other content areas. Thailand's and Philippines eighth graders' weakest content area was Algebra while that of Indonesia's eighth graders was Measurement.

Table 5A

Average achievement in mathematics content areas

Country	Average Scale Score		
	Fractions & Number Sense (61 items)	Measurement (24 items)	Data Representation, Analysis, & Probability (21 items)
Singapore	608 (5.6)	599 (6.3)	562 (6.2)
Malaysia	532 (4.7)	514 (4.6)	491 (4.0)
International Average	487 (0.7)	487 (0.7)	487 (0.7)
Thailand	471 (5.3)	463 (6.2)	476 (4.0)
Indonesia	406 (4.1)	395 (5.1)	423 (4.4)
Philippines	378 (6.3)	355 (6.2)	406 (3.5)

Numbers within ( ) give the standard errors

Table 5B
Average achievement in mathematics content areas – continued

Country	Average Scale Score	
	Geometry (21 items)	Algebra (35 items)
Singapore	560 (6.7)	576 (6.2)
Malaysia	497 (4.4)	505 (4.8)
International Average	487 (0.7)	487 (0.7)
Thailand	484 (4.4)	456 (4.9)
Indonesia	441 (5.1)	424 (5.7)
Philippines	383 (3.4)	345 (5.8)

Numbers within ( ) give the standard errors

TIMSS-1999 INTERNATIONAL BENCHMARKS OF MATHEMATICS ACHIEVEMENT

The International benchmarks presented as part of the TIMSS-1999 data (Mullis et al., 2000) help to provide participating countries with a distribution of the performance of their eighth graders in an international setting. For the participating countries the proportions of their students reaching these benchmarks perhaps speak for certain strengths and weaknesses of mathematics education programs in their countries. The benchmarks delineate performance of the top 10%, top quarter, top half, and lower quarter of students in the countries participating in TIMSS-1999. The analysis of performance at these benchmarks in mathematics suggests that three primary factors appeared to differentiate performance among the four levels:

- the mathematical operation required
- the complexity of the numbers or number system
- the nature of the problem situation.

Table 6 shows the percentage of students from SEA reaching TIMSS-1999 International benchmarks of mathematics achievement. It is interesting to note that for Singapore almost half of their eighth graders were among the top 10% and nearly all of them were amongst the top 75% of the participants in TIMSS-1999. More than a third of the eighth graders from

Malaysia were amongst the top 25% of the participants, though only 12 % were amongst the top 10%. About four fifths of the eighth graders from Thailand were among the top 75% of the participants, though only 4 % and 16 % were amongst the top 10 % and top 25 % respectively. Only about a half of the eighth graders from Indonesia and a third of the eighth graders from Philippines were among the top 75 % of the participants in TIMSS-1999. For both Indonesia and Philippines the percentages of eighth graders at all benchmarks were significantly low and merit attention.

Table 6

Percentages of Students Reaching TIMSS 1999 International Benchmarks of Mathematics Achievement

Country	Top 10% (90^{th} percentile)	Upper Quarter (75^{th} percentile)	Median (50^{th} percentile)	Lower Quarter (25^{th} percentile)
Singapore	46 (3.5)	75 (2.7)	93 (1.3)	99 (0.3)
Malaysia	12 (1.4)	34 (2.4)	69 (2.2)	94 (0.8)
Thailand	4 (0.8)	16 (1.8)	44 (2.6)	81 (1.6)
Indonesia	2 (0.4)	7 (0.9)	22 (1.4)	52 (2.2)
Philippines	0 (0.1)	1 (0.5)	8 (1.4)	31 (2.5)

Numbers within ( ) give the standard errors

What do these benchmarks mean? To make them more meaningful, the profiles of the students reaching these International benchmarks and examples of items they are mostly likely to answer correctly are explained as follows:

Top 10 % International benchmark

These students can organize information, make generalizations, and explain solution strategies in non-routine problem solving situations. They can organize information and make generalizations to solve problems; apply knowledge of numeric, geometric, and algebraic relationships to solve problems (e.g., among fractions, decimals, and percents; geometric properties; and algebraic rules); and find the equivalent forms of algebraic expressions. Examples 1 and 2 are representative items of this benchmark that students reaching the benchmark are likely to answer correctly.

Example 1

Content area: Data representation, Analysis and Probability

Performance Expectation: Communicating & Reasoning

Description: Selects relevant information from two advertisements to solve a complex word problem involving decimals.

Chris plans to order 24 issues of a magazine. He reads the following advertisements for two magazines. *Ceds* are the units of currency in Chris' country.

Teen Life Magazine	**Teen News Magazine**
24 issues First four issues FREE The rest 3 *ceds* each	24 issues First six issues FREE The rest 3.5 *ceds* each

Which magazine is the least expensive for 24 issues? How much less expensive?

Show your work.

Percent correct:

Singapore	-	57;	Thailand	-	21;
Malaysia	-	19;	Indonesia	-	5;
Philippines	-	3;	International	-	24.

Example 2

Content Area: Algebra

Performance Expectation: Investigating & Solving Problems

Description: Given the initial terms in a sequence and, for example, the 50th term of that sequence, generalizes to find the next term.

The figures show four sets consisting of circles.

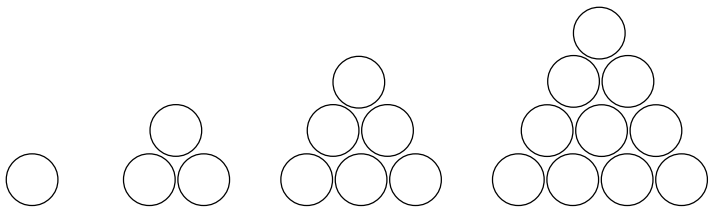


Figure 1 *Figure 2* *Figure 3* *Figure 4*

a) Complete the table below. First fill in how many circles make up Figure 4. Then, find the number of circles that would be needed for the 5th figure if the sequence of figures is extended.

Figure	Number of circles
1	1
2	3
3	6
4	
5	

b) The sequence of figures is extended to the 7th figure. How many circles would be needed for Figure 7?

Answer:_____

c) The 50th figure in the sequence contains 1275 circles. Determine the number of circles in the 51st figure. Without drawing the 51st figure, explain or show how you arrived at your answer.

Percent correct:

Singapore	-	65;	Malaysia	-	37;
Thailand	-	25;	Indonesia	-	24;
Philippines	-	9;	International	-	30.

Upper Quarter International benchmark

These students can apply their understanding and knowledge in a wide variety of relatively complex situations. They can order, relate and compute with fractions and decimals to solve word problems; solve multi-step word problems involving proportions with whole numbers; solve probability problems; use knowledge of geometric properties to solve problems; identify and evaluate algebraic expressions and solve equations with one variable. Examples 3 and 4 are representative items of this benchmark that students reaching the benchmark are likely to answer correctly.

Example 3

Content Area: Fractions and Number Sense

Performance Expectation: Investigating & Solving Problems

Description: Solves a multi-step word problem that involves dividing a quantity in a given ratio.

John sold 60 magazines and Mark sold 80 magazines. The magazines were all sold for the same price. The total amount of money received for the magazines was $700. How much money did Mark receive?

Answer:_____

Percent correct:

Singapore	-	84;	Malaysia	-	65;
Thailand	-	38;	Indonesia	-	27;
Philippines	-	12;	International	-	44.

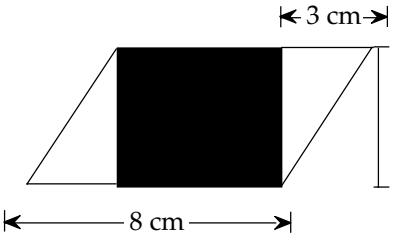
Example 4

Content Area: Measurement

Performance Expectation: Investigating & Solving Problems

Description: Find the area of a rectangle contained in a parallelogram of given dimensions.

The figure shows a shaded rectangle inside a parallelogram.



What is the area of the shaded rectangle?

Answer:_____

Percent correct:

Singapore	-	83;	Malaysia	-	56;
Thailand	-	33;	Indonesia	-	20;
Philippines	-	6;	International	-	43.

MEDIAN INTERNATIONAL BENCHMARK

These students can apply basic mathematical knowledge in straightforward situations. They can add or subtract to solve one-step word problems involving whole numbers and decimals; identify representations of common fractions and relative sizes of fractions; solve for missing terms in proportions; recognize basic notions of percents and probability; use basic properties of geometric figures; read and interpret graphs, tables, and scales; and understand simple algebraic relationships. Examples 5 and 6 are representative items of this benchmark that students reaching the benchmark are likely to answer correctly.

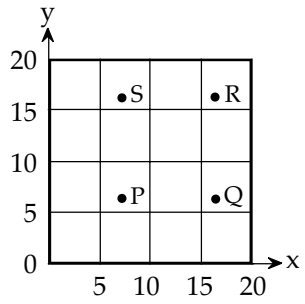
Example 5

Content Area: Geometry

Performance Expectation: Using Routine Procedures

Description: Locates the point on a grid with 5-unit divisions when the point lies between the grid lines.

Which point on the graph could have coordinates (7,16)?



A. Point P

B. Point Q

C. Point R

D. Point S

Percent correct:

Singapore	-	80;	Malaysia	-	78;
Indonesia	-	50;	Thailand	-	37;
Philippines	-	23;	International	-	58.

Example 6

Content Area: Algebra

Performance Expectation: Knowing

Description: Identifies the linear equation corresponding to a given verbal statement involving a variable.

n is a number. When n is multiplied by 7, and 6 is then added, the result is 41.

Which of these equations represents this relation?

A. $7n + 6 = 41$

B. $7n - 6 = 41$

C. $7n \times 6 = 41$

D. $7(n + 6) = 41$

Percent correct:

Singapore	-	89;	Thailand	-	67;
Malaysia	-	57;	Indonesia	-	37;
Philippines	-	19;	International	-	65.

Lower Quarter International benchmark

These students can do basic computations with whole numbers. The few items that anchor at this level provide some evidence that students can add, subtract, and round with whole numbers. With decimals of the same order i.e. the same number of decimal places, they can subtract with multiple regrouping. Students can round whole numbers to the nearest hundred. They recognize some basic notation and terminology. Examples 7 and 8 are representative items of this benchmark that students reaching the benchmark are likely to answer correctly.

Example 7

Content Area: Fractions and Number Sense

Performance Expectation: Using Routine Procedures

Description: Subtracts a three-decimal number from another with multiple regrouping.

Subtract: 4.722 – 1.935 =

A. 2.787

B. 2.797

C. 2.887

D. 2.897

Percent correct:

Malaysia	-	92;	Singapore	-	90;
Thailand	-	83;	Indonesia	-	78;
Philippines	-	69;	International	-	77.

Example 8

Content Area: Fractions and Number Sense

Performance Expectation: Using Complex Procedures

Description: Rounds to estimate the sum of two three-digit numbers.

The sum 691 + 208 is closest to the sum

A. 600 + 200

B. 700 + 200

C. 700 + 300

D. 900 + 200

Percent correct:

Singapore	-	97;	Malaysia	-	88;
Thailand	-	77;	Indonesia	-	54;
Philippines	-	53;	International	-	80.

The Mathematics Curriculum

In comparing achievement across countries, it is important to consider differences in students' curricular experiences and how these may affect the mathematics they have studied. TIMSS-1999 database (Mullis, et al., 2000) provides information concerning the intended mathematics curriculum (Robitaille, & Dirks, 1982) of the participating countries.

Type of Intended Curriculum

For all the five South East Asian countries (Indonesia, Malaysia, Philippines, Singapore and Thailand) that participated in TIMSS-1999, the intended mathematics curriculum was a National curriculum often having the ministry of education being exclusively responsible for the major decisions governing the direction of education.

Methods for Supporting and Monitoring Curriculum Implementation

Different education systems may use different ways to achieve the best match between their intended and implemented curriculum (Robitaille, & Dirks, 1982). In Malaysia, Singapore and Thailand the methods used to support or monitor curriculum implementation were:

- pre-service teacher education,
- in-service teacher education,
- mandated or recommended textbook(s),
- instructional or pedagogical guide,
- ministry notes and directives,
- system of school inspection or audit.

In Indonesia and the Philippines, the methods were all of the above except pre-service teacher education.

Examinations and Assessments in Mathematics

Public examinations help to select students for university or academic tracks in secondary school, while system-wide assessments in mathematics primarily inform policy makers about matters such as national standards of achievement of the intended curriculum objectives, strengths and

weaknesses in the curriculum and how it is being implemented, and whether educational achievement is improving or deteriorating. Table 7 shows the grade levels at which students in SEA take public examinations and system-wide assessments in mathematics. Indonesia appears to be the only SEA country that participated in TIMSS-1999 that does not seem to have a robust system-wide assessment agenda.

Table 7

Grades at which Public Examinations & System-wide Assessments are conducted for students in SEA

Country	Public Examinations	System-wide Assessments
Indonesia	6, 9, 12	-
Malaysia	6, 9, 11, 13	6, 9, 11, 13
Philippines	6, 10	6, 10
Singapore	6, 10, 12	6, 10, 12
Thailand	12	6, 9, 12

Instructional Time for Mathematics

The percentage of time recommended for the study of mathematics at any grade reflects the importance attached to the learning of mathematics in the school curriculum. Table 8 shows the percentages of time recommended for the subject mathematics at three different grade levels for a country. This data shows some trend as regards to the importance of mathematics in the school curriculum of a particular country. From Table 8, it appears that in both Singapore and Malaysia, there appears to be a strong emphasis on the learning of mathematics in the primary school years. For both Indonesia (14 %) and Thailand (8 %), the percentage of instructional time recommended for mathematics appears to be constant across the grade levels. In the Philippines the instructional time recommended decreases (from 12 % to 10 %) gradually as the grade levels increase. At grade 8, Singapore appears to have the highest percentage (15%) of time recommended for mathematics, when compared with the other South East Asian countries that participated in TIMSS-1999.

Table 8
Instructional time recommended for Mathematics in SEA

Country	Grade 4	Grade 6	Grade 8	Comments
Indonesia	14 %	14 %	14 %	-
Malaysia	20 %	20 %	3 %	From Grade 8 through secondary school, the instructional time specified for mathematics remains about the same. The mathematics curriculum emphasizes understanding concepts and mastering processes. Emphasis for the higher-level processes increases as students progress through school.
Philippines	12 %	11 %	10 %	To supplement the regular mathematics program, enrichment topics and activities are included in mathematics for Grade 7, especially in the special science classes/schools.
Singapore	22 %	20 %	15 %	Students are required to study mathematics, English and the mother tongue language throughout primary and secondary school. Pupils who are planning to pursue further study in mathematics or a related discipline are offered an additional mathematics subject in Grade 9.
Thailand	8 %	8 %	8 %	There is no change in content, but there is change in depth.

Individual Differences and Mathematics Instruction

It is a fact that not all persons have the same ability or aptitude for any cognitive activity or skill. So, similarly not all students have the same ability or aptitude for the study of mathematics. In Malaysia, Philippines, Singapore and Thailand there was differentiation of instruction for students with different abilities or interests. In Singapore different curricula were used for different ability groups of students. In Malaysia, Philippines and Thailand the same curricula were available for all students but teachers adapted the curricula to meet the needs of different ability groups of students. In Indonesia it appears that the same curricula were used for all ability groups of students with little or no adaptations.

Emphasis on Approaches and Processes

The major characteristics of any intended curriculum are often presented in the form of emphasis placed on approaches and processes by which the content matter is to be transmitted. Table 9 shows the relative emphasis given to various aspects of mathematics instruction in the intended curriculum by the five countries in SEA that participated in TIMSS-1999. All five countries placed major emphasis on *mastering basic skills* and *understanding concepts*. Malaysia, Philippines and Singapore also placed major emphasis on *real-life applications of mathematics* while Indonesia and Thailand placed only moderate emphasis on it. The Philippines and Singapore placed major emphasis on *communicating mathematically* while Indonesia, Malaysia and Thailand placed only moderate emphasis on it. Indonesia and Singapore placed major emphasis on *solving non-routine problems* while Malaysia and Philippines placed only moderate emphasis on it only. None of the five countries placed major emphasis on *deriving formal proofs, working on mathematics projects, integrating of mathematics with other school subjects, thematic approach* and *multicultural approach*. Indonesia, The Philippines and Singapore placed major emphasis on *assessing student learning*, while Malaysia and Thailand only placed moderate emphasis on it.

Table 9
Emphasis on Approaches and Processes of the Mathematics Curriculum in SEA

	Indonesia	Malaysia	Philippines	S'pore	Thailand
Mastering Basic Skills	xxx	xxx	xxx	xxx	xxx
Understanding Concepts	xxx	xxx	xxx	xxx	xxx
Real-life Applications of Mathematics	xx	xxx	xxx	xxx	xx
Communicating Mathematically	xx	xx	xxx	xxx	xx
Solving Non-Routine Problems	xxx	xx	xx	xxx	x
Deriving Formal Proofs	x	x	xx	xx	x
Working on Mathematics Projects	xx	x	xx	x	x
Integrating of Mathematics with Other School Subjects	xx	xx	x	x	xx
Thematic Approach	xx	xx	x	x	x
Multicultural Approach	x	x	x	x	x
Assessing Student Learning	xxx	xx	xxx	xxx	xx

xxx – Major Emphasis; xx – Moderate Emphasis; x – Minor/No Emphasis

Have Students been Taught the Topics tested by TIMSS –1999?

Although the Intended curricula of the participating countries do confirm that students at the eighth grade would have been taught most of the topics in the five content areas tested, to get a better picture of the implemented curriculum teachers of the students who participated in TIMSS-1999 were asked to provide information about the topics again. With the help of a questionnaire they were asked to indicate against the topics that were being tested if their students had been taught the topic in grade 8, at an earlier grade or not at all. This data is presented in Exhibits 5.12 – 5.16 in Mullis et al., (2000). Table 10 shows a summary of this data. The average of the percentages for all topics within a particular content area was found for the respective countries.

Table 10
Average of Percentage of students taught topics tested in the content areas

	Average percentages across topics in content areas				
Country	Fractions & Number Sense	Measurement	Data Representation, Analysis & Probability	Geometry	Algebra
Indonesia	99	94	94	74	87
Malaysia	98	93	42	76	93
Philippines	94	78	41	48	66
Singapore	100	99	67	89	98
Thailand	97	89	64	81	84

From Table 10, it is clear that for all the five countries, the content area Fractions and Number Sense was their forte, and rightfully in the TIMSS-1999 tests the abundance of items were on this particular content area. It is also clear from the data in Table 10 that some countries may have been at a disadvantage with regards to certain content areas. However, based on the data in Table 10 alone, it is not possible to justify the rankings of the five South East Asian countries that participated in TIMSS-1999.

DISCUSSION

The TIMSS-1999, data show that the performance of eighth graders in mathematics from SEA differ significantly. Eighth graders from Singapore were at the top of the ranking table while their counterparts from Indonesia and the Philippines were almost at the opposite end of the table. A review of their intended mathematics curriculum does not suggest any reasonable correlation between any aspect of the intended curriculum and the average scale scores of the countries.

However, it appears that introducing the intended mathematics curriculum to teachers during their pre-service teacher education, having a robust system-wide assessment agenda to monitor the implementation of the curriculum, adequate emphasis on the learning of mathematics (in terms of percentage of instructional time), providing for individual differences by way of different curriculum and approaches, and emphasizing certain approaches and processes during the implementation of the curriculum

may amongst other factors provide possible leads to good performance of students in mathematics.

From the national reports on TIMSS (Research & Testing Division, MOE; 1966), TIMSS-1999 (Research & Evaluation Branch, MOE; 2000) and an analysis by Kaur (2002) the following are the possible factors that may have contributed to the high performance of Singapore's eighth graders in mathematics.

- *The education system*

  Singapore has a centralized education system. The Ministry of Education is the national authority that provides guidelines in the areas of curriculum and assessment. This ensures a high degree of homogeneity and coherence in curriculum coverage. The streaming of pupils according to ability and the availability of suitable curriculum enables teachers to be focused in their teaching and also provide for individual needs of the students.

- *School organization and environment*

  Schools in Singapore appear to be well organized in terms of high availability of resources (e.g. computers, space and materials) for instruction, despite having very large enrolments. The school atmosphere appeared to be conducive to teaching and learning as relatively few school principals reported absenteeism, late-coming and discipline as serious problems in their schools compared with their counterparts in other countries that participated in TIMSS and TIMSS-1999. Principals of Singapore schools also reported working long hours performing various school activities, thereby indicating their high level of commitment to their role.

- *Mathematics curricula implementation*

  The mathematics syllabuses developed by the Ministry of Education in Singapore, which were revised in 1990 and again in 2000, place emphasis on the development of mathematical concepts and skills, and the ability to apply them to solve problems. The syllabuses are embedded in a framework, shown in figure 1 (MOE, 2000a; 2000b), that enables students to develop thinking processes as well as attitudes and metacognition necessary for problem-solving.

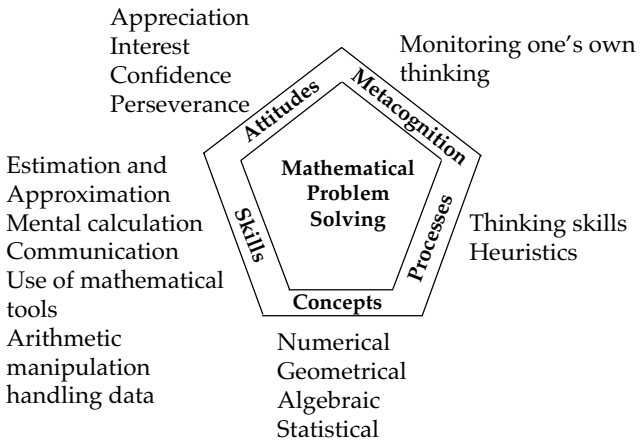


Figure 1: Framework of the Mathematics Curriculum (MOE, 2000a; 2000b)

Heads of mathematics departments and mathematics teachers are familiarized with the framework of the mathematics syllabuses periodically through school-based, pre-service, in-service and national level briefings and workshops. In Singapore, the gap between the intended and implemented curriculum is very narrow. This is so as the Ministry of Education closely regulates and monitors the implementation of the mathematics curriculum in all schools. It provides schools with titles of recommended texts, pedagogical / instructional guides for teachers, assessment guides and set achievement standards. The Ministry also supports schools with a system of directives and notes, as well as school inspection. Teachers place major emphasis on mastering basic skills, understanding mathematical concepts, applying mathematics to real life situations, communicating mathematically, solving non-routine problems and assessing student learning during mathematics lessons.

- *Qualifications and working ethos of teachers*

  Most of the teachers in schools are certified and have the relevant mathematics qualifications. Compared to their international counterparts, mathematics teachers in Singapore put in the highest number of hours (ten hours per week) in marking and grading students' work, and in lesson planning. In addition to their scheduled

teaching and extra-curricular duties, they spent on the average another three hours per week on keeping student records and doing other administrative tasks. The dedication and effort on the part of Singapore teachers would have contributed in no small way to the outstanding mathematics achievement of all Singapore students.

- *Training and professional development of teachers*

  Professional upgrading of mathematics teachers is an ongoing process in Singapore. Teachers are entitled to 100 hours of in-service training each year. The Ministry of Education continually organizes workshops, in-service courses and seminars to upgrade teachers' knowledge and skills, to equip them with effective teaching strategies, and to keep them abreast of recent developments in mathematics education. Teachers are encouraged to engage in lifelong learning and at the school and national level many initiatives are in place to facilitate sharing of teaching ideas and good practices. The National Institute of Education is actively engaged in the constant upgrading of mathematics teachers via the Diploma level and the Master Degree level courses. The Association of Mathematics Educators and the Singapore Mathematical Society also have an active role in the professional development of mathematics teachers in Singapore.

- *Home environment and support*

  In Singapore, society as a whole places a high premium on success at school. The virtue of hard work and the need to strive for excellence are ingrained in students from an early age. Parents have high expectations of their children and are willing to invest in their children's education in terms of resources and 'out-of-school' help. The TIMSS findings showed that, compared to their counterparts in other countries, Singapore students were amongst the most hardworking in the world in terms of the amount of time spent studying or doing homework in mathematics. They had good access to educational resources (e.g. study table, dictionary, relevant books) for study at home generally. TIMSS-1999 data show that 80 % of the students reported that they had a computer at home and this is 30% more than that reported in TIMSS. It appears that society as a whole

is well informed of educational initiatives and prepared to support them.

- *Students' attitude and expectations*

  The majority of Singapore students liked mathematics. They regarded doing well in mathematics as important. Nearly 60 % of the eighth graders indicated that they expected to finish university education. Almost 90 % of the students in TIMSS-1999 indicated that they had a reasonable self-concept in mathematics.

CONCLUSION

Having speculated what may contribute towards high achievement in mathematics based on the data in the paper and from the review of the factors that may have contributed towards the high achievement of Eighth Graders in Singapore, it appears that central to high achievement in mathematics are:

- People

  Good teachers, keen students, dedicated school leaders, enthusiastic parents, and definitely society as a whole with a vision.

- Environment

  Learning environments must be supportive and conducive both at home and in school

- Mathematics curriculum

  Relevant with sufficient depth and breadth

- Systems

  Good and efficient monitoring and assessment methods.

TIMSS and TIMSS-1999 have provided the participating countries with a wealth of data and also an objective measure of its mathematics education against world benchmarks. For some countries these studies have affirmed that their mathematics education programs are sound, while for others they have provided an impetus to re-look at some aspects of their mathematics curriculum.

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