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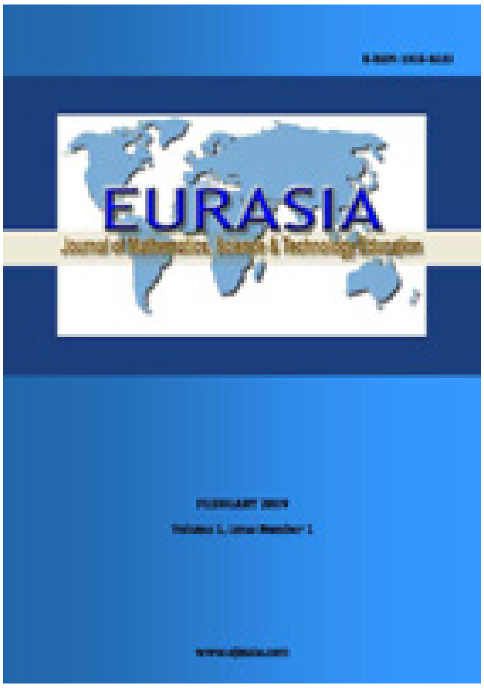

Student Factors and Mathematics Achievement: Evidence from TIMSS 2007

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Mathematics learning and achievement is one area of research that has gained momentum in recent years because of its importance as a subject in the school curriculum and its usefulness as a prerequisite for developing the quantitative and analytical skills. However, studies on factors affecting mathematics achievement in Malaysia are limited both in terms of the number as well as the scope. It is the aim of this study to take a closer look at the relationship between student and background factors and mathematics achievement among secondary school students in Malaysia using the most recent Trend in International Mathematics and Science Study (TIMSS) 2007 data. The results suggested that female, educational resources, students' attitude, homework and school environment have significant positive effect on mathematics performance. The two factors having opposite effects are age of the students and language spoken at home. Mathematics performance is found to decrease with increasing age and students who did not speak the language of the test at home have significantly higher scores than those who did. These results have important implications especially for educators and policy makers as well.

Keywords: conceptual understanding, performance, pre-service teacher, science process skills

INTRODUCTION

Many debates were raised in the last few years among the general public, in particular, parents, politicians and educators concerning the teaching of mathematics in secondary schools in Malaysia. This is primarily due to the policy changes made by the government with respect to the medium of instruction to be used in government aided schools. Since the early 1980s the national language, Bahasa Malaysia, was gradually made compulsory as the medium of instruction in all national secondary schools and institutions of higher learning (Mauzy, 1985). Then in early 2000s an announcement came from the Ministry of Education that beginning 2003, the teaching of mathematics and science in all fully aided government secondary schools will have to be conducted in English. The move was part of the government's long term strategy to enhance its efforts in preparing and developing its human capital in the globalized world. However, there were concerns with regard to the implementation especially during the transition period. These concerns centered on the state of readiness on the part of the students, majority of them were not proficient in English, as well as the question of competencies and preparedness on the part of the teachers to effectively teach in English (Idris, Cheong, Mohd Nor, Abdul Razak & Md Saad, 2007). As a result of the many issues raised coupled with the mounting pressures from concerned public with the declining trend in mathematics achievement including Malaysia's performance in Trend in Mathematics and Science Study (TIMSS), in 2009 the government made another decision to revert to the use of Bahasa Malaysia in the teaching of science and mathematics after many rounds of meetings and discussions with various stake holders.

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State of the literature

- Though science process skills form an integral part of inquiry teaching, and emphasized in science education reforms, some studies have demonstrated that pre-service teachers have poor understanding of the process skills .
- A few studies in the domain of science process skills rarely discuss elementary education pre-service teachers' conceptual understanding of and performance on the science process skills.

Contribution of this paper to the literature

- Our pre-service teachers' limited conceptual understanding of the science process skills is consistent with the findings in previous studies
- However, a unique contribution to the literature is that whilst pre-service teachers were unable to provide correct definitions of the science process skills, they performed well on the test that involved novel situations of the process skills. A possible explanation for this good performance could be that the performance test items were presented in a real-world type situation, which could have assisted the pre-service teachers in solving them because they were familiar with the contexts.
- In our study, pre-service teachers' poor conceptual understandings is of great concern and a call to action on the part of science teacher education and professional development programs.

Malaysia's first participation in TIMSS was in 1999 in which the country's average achievement of 519 had earned the 10th position among 38 participating countries. TIMSS 2003 placed Malaysia in 16th position out of 46 countries with an average achievement of 508 followed by a plunge to 20th position among 50 countries with an average score 474 in TIMSS 2007. It should be noted that all the three TIMSS were conducted in the national language, Bahasa Malaysia and that the data from TIMSS 1999 and TIMSS 2003 showed that students who did not speak the language of the test at home had significantly higher scores than students who always speak the language of the test at home (Ismail & Awang, 2008). It is important to note that students who did not speak Bahasa Malaysia were predominantly Chinese and Indians while those who speak the national language at home were almost all Malays.

There are numerous research in the literature concerning mathematics teaching and learning as well as mathematics performance especially so in the recent years considering the importance of the subject across the globe (Swetz, Langgulung & Johar, 1983; Alkhateeb, 2001; McGraw, Lubienski & Strutchens, 2006; Ramirez, 2006; Grootenboer & Hemmings, 2007; Tella, 2007; House & Telese, 2008; Ismail & Awang, 2008). These studies found many factors affecting mathematics learning and performance ranging from students' background, attitudes and motivation, teachers as well as school characteristics. For example, Alkhateeb (2001), McGraw et al (2006), Grootenboer & Hemmings (2007) and Ismail & Awang (2008) examined the relationship between background factors of the students including gender, and mathematics achievement in United Arab Emirates, United States and Malaysia, respectively. While Tella (2007) and Wang (2007) investigated the impact of motivation and self-concept on mathematics, House & Telese (2008) and Ramirez (2006) did a comparative evaluation of the determining factors of mathematics of mathematics achievement across countries. Expectedly it should also be noted that different studies show different results depending on countries and contexts as well as in terms of the motivating factors and the extent to which these factors have on mathematics learning and performance. Hence, by using the most recent TIMSS 2007 data, the aim of this study was to take a closer look at the relationship between student and background factors and secondary school students' mathematics achievement in Malaysia.

MATERIAL AND METHOD

The data used in this study is generated from TIMSS's most recent database. The information was collected from the Malaysian eight graders in 2007. A total of 4466 pupils from 150 schools participated in the study. TIMSS selected school samples using a simple random sampling from all the secondary schools in Malaysia. For each school, a single classroom of eighth grade pupils was selected at random. Pupils from these selected classes were asked to complete pupils' questionnaires. Details of the sampling procedure, background information of the students, teachers and schools as well as mathematics questions and achievement can be found in TIMSS reports (Olson, Martin & Mullis, 2008). For this paper, data on mathematics achievement are analyzed using t-test, ANOVA and multiple linear regression models.

RESULTS

Students' Background

As Table 1 shows all of the students' demographic background variables considered in this study are significant in explaining the variation in mathematics achievement. The mean age of the Malaysian students (not shown in the table) is 14.33 years with standard deviation of 0.34. The Pearson correlation is -0.059, indicating that age is negatively correlated with mathematics achievement. The results in Table 1 also show that girls scored significantly higher than boys. This is consistent with the results from some countries involved in TIMSS. These countries include Serbia, Macedonia, Armenia, Moldovo, Singapore, the Phillipines, Cyprus, Jordan and Bahrain (Mullis, Martin & Foy, 2008). Table 1 also suggests that students from homes where the language of the test is always spoken at home had lower mathematics achievement than those who speak the national language less frequently and that achievement in mathematics increases significantly with increasing level of parents' education. The results in Table 1 are also found to be consistent with the previous findings of TIMSS 1999 and TIMSS 2003 data involving eighth grade Malaysian students.

Educational Resources

Three educational resources were incorporated in this analysis namely the number of books in the home, having a study desk and computer ownership in the home. Significant relationships were observed between all three educational resources and mathematics achievement. Majority of the students reported having one to two shelves of books (67%) and a high proportion of them own a study desk (86%) and use computer either at home, school or other places (91%) while about 60 percent actually own a computer. There was a clear-cut relationship between number of books in the home and mathematics achievement where the score increases significantly as the number of books in home increases. In addition to books, it can be observed that students having study aids such as study desk and computer at home scored significantly higher than those without. Using a computer may be more important for a student than just having one at home. Students reported using a computer both at home and at school had higher mean mathematics achievement as compared to those reported using a computer at only at one location or do not use computer at all.

Attitudes towards Mathematics

Attitude towards mathematics considered in this paper were represented by three variables, the first being students' positive thinking about mathematics which indicates how students feel about the subject itself as well as learning the subject matter. The Index of Students' Positive Affect toward Mathematics (PATM)

Table 1. Differences in mean scores of background variables

Variable	Description	Label	Category	%	Mean	SD	p-value
SEX	Gender of Student	1	Girl	52.9	479.88	75.94	<0.001
		0	Boy	47.1	468.27	80.37	
SPEAK		1	Never	10.1	502.93	90.48	<0.001
		2	Sometimes	29.0	489.80	84.10	
		3	Almost Always	14.4	489.38	69.03	
		4	Always	46.5	454.07	68.60	
PHE		1	Do Not Know	10.8	442.98	82.03	<0.001
		2	Less than Lower-Secondary Education	6.5	448.58	73.86	
		3	Completed Lower-Secondary Education	19.5	453.30	70.90	
		4	Completed Upper-Secondary Education	33.8	477.50	74.47	
		5	Post-Secondary Education but Not University	16.9	495.24	2.16	
		6	University Degree Completed	12.4	512.01	81.69	

Table 2. Differences in mean scores of Educational Resources

Variable	Description	Label	Category	%	Mean	SD	p-value
BOOK		1	None or Very Few (0 to 10 books)	19.0	437.39	72.49	<0.001
		2	One Shelf (11 to 25 books)	38.7	460.79	72.99	
		3	One Bookcase (26 to 100 books)	28.2	494.48	73.599	
		4	Two bookcases (101 to 200 books)	9.1	514.48	70.25	
		5	Three or more bookcases (200+ books)	5.0	535.44	79.09	
DESK		1	Yes	86.0	479.38	76.81	<0.001
		0	No	14.0	446.48	80.78	
COMP		1	Yes	59.3	498.29	76.86	<0.001
		0	No	40.7	440.19	66.49	
COUSE	Computer Use	1	Do not Use PC at All	8.5	425.27	61.16	<0.001
		2	Use PC only at Places Other than Home and School	10.7	445.66	59.54	
		3	Use PC at School but Not at Home	21.3	444.18	69.11	
		4	Use PC at Home but Not at School	31.2	490.66	76.75	
		5	Use PC at Home and at School	28.3	511.29	73.42	

was created based on three statements: 'I enjoy learning mathematics', 'Mathematics is not boring' and 'I like mathematics'. The students were assigned to either one of the three levels of the index, high, medium or low, depending on their responses to the three statements. From the mean achievement scores obtained, there is no specific pattern detected and post-hoc test suggests that no difference between mean scores of medium and low index and hence in this analysis, these two groups are combined, 1 = high and 0 = medium or low. Table 3 shows that, on average, students with high index of PATM can be said to gain higher mathematics achievement as compared to those in the medium or low level of index.

The second measure of attitude towards mathematics is how students think of their own abilities in mathematics that may affect their mathematics performance. For this purpose, the Index of Students' Self-Confidence in Learning Mathematics (SCM) was created based on responses to four statements about students' mathematics ability: 'I usually do well in mathematics', 'Mathematics is easier for me than many of my classmates', 'I am good at mathematics' and 'I learn things quickly in mathematics'. As we can observe in Table 3, higher index is associated with higher mathematics achievement.

The last variable in this category is the Index of Students' Valuing Mathematics (SVM) which is created based on statements such as 'I think learning mathematics will help me in my daily life', 'I need mathematics to learn other school subjects', 'I need to do well in mathematics to get into the university of my choice' and 'I need to do well in mathematics to get the job I want'. Consistent with the first two indices, there was significant positive relationship between SVM and mathematics achievement.

Homework and School Environment

The first variable considered in this section is the Index of Time Students Spend Doing Mathematics Homework (TMH) in a normal school week. It might be expected that students who are assigned homework and who spend more time on doing the assignment would have higher achievement than students who do little or no homework. The amount of time they spend on the homework can also be perceived as how interested the students are on the subject. TIMSS constructed an index that assigns students to a high, medium and low level on the basis of the frequency of homework they are assigned each week and the amount of time they spend on it. While the results in TIMSS report (Mullis et al, 2008) show that the relationship between TMH and mathematics achievement varies from country to country, there exists positive relationship between the two variables. This implies that the more Malaysian students spend time doing mathematics homework, their achievement in mathematics would be higher.

The other variable considered in this study is Index of Students' Perception of Being Safe in School (SPBSS). The results in Table 4 show that the higher the level of SPBSS, the higher the mean of mathematics achievement among Malaysian students.

Joint Effect Variables on Mathematics Achievement

The results in Table 5 show that all thirteen variables were significant contributors to the explanation of variance in mathematics achievement among Malaysian students and all of them, except age of a student, have positive association with achievement. As mentioned

Table 3. Differences in mean scores of Students' Attitudes towards Mathematics

Variable	Description	Label	Category	%	Mean	SD	p-value
PATM	Index of Students' Positive	0	Medium or Low	27.8	443.55	72.74	<0.001
	Affect Toward Mathematics	1	High	72.2	486.49	76.99	
SCM	Index of Students' Self-Confidence in	1	Low	22.3	451.98	63.38	<0.001
	Learning Mathematics	2	Medium	50.1	458.49	74.68	
		3	High	27.6	522.24	75.22	
SVM	Index of Students' Valuing Mathematics	1	Low	3.2	418.90	87.57	<0.001
		2	Medium	21.7	461.42	81.73	
		3	High	75.1	480.74	75.35	

Table 4. Differences in mean scores of Home and School Environment

Variable	Description	Label	Category	Mean	SD	p-value
TMH	Index of Time Students Spend Doing	1	Low	448.09	84.82	<0.001
	Mathematics Homework	2	Medium	474.72	80.30	
		3	High	486.13	69.94	
SPBSS	Index of Student Perception of Being Safe	1	Low	452.91	83.01	<0.001
	in School	2	Medium	463.64	78.29	
		3	High	487.08	75.18	

Table 5. Multiple Linear Regression Results of Mathematics Achievement

Variable	Coefficient	SE	Standardized Coefficient	t-statistic	p-value	VIF
CONSTANT	324.362	41.821		7.756	<0.001	
SEX	4.442	1.945	0.029	2.284	0.022	1.043
AGE	-8.896	2.844	-0.039	-3.129	0.002	1.022
SPEAK	-15.392	0.927	0.213	16.598	<0.001	1.086
PHE	6.079	0.715	0.112	8.506	<0.001	1.148
BOOK	12.063	0.994	0.164	12.138	<0.001	1.200
DESK	5.521	2.830	0.024	1.951	0.051	1.040
COMP	15.070	2.806	0.095	5.371	<0.001	2.086
COUSE	9.987	1.102	0.160	9.062	<0.001	2.062
SCM	21.837	1.497	0.201	14.590	<0.001	1.253
SVM	10.724	1.988	0.070	5.395	<0.001	1.128
PATM	14.083	2.437	0.081	5.779	<0.001	1.288
TMH	11.408	1.436	0.099	7.946	<0.001	1.024
SPBSS	14.264	1.500	0.120	9.512	<0.001	1.047

earlier, although the younger children are performing better in mathematics achievement as compared to their older counterparts, the variation in age is not that wide since almost all of the students are aged about 14 years. The model is significant with an F ratio of 189.235 a p-value of less than 0.001 indicating that the variables included in this analysis contribute significantly to the predictive ability. The adjusted R-square value indicates that about 37% of the variance in mathematics achievement is explained by the thirteen variables. This relatively small value may be due to the fact that other variables related to teachers, curriculum, and schools were not included in the analysis. Table 5 also shows that there is no serious collinearity among the variables since all of the variance inflation factor (VIF) values are below the common cutoff threshold of 10.

To investigate the relative importance of each variable, the standardized beta coefficients are used. Table 6 shows the results of sorting the variables according to the absolute value of the coefficients in the descending order. The results suggested that infrequent use of the language of test at home, students' self-confidence in learning mathematics, number of books in home, computer use, students' perception of being safe in home and parents' highest education level have the greatest influence on mathematics achievement. Although significant, the other seven variables which consist of time spend on mathematics homework, computer ownership, students' positive affect towards mathematics, students valuing mathematics, age of students, gender of the student and having a study desk in home do not merit the attention that should be accorded to the other five variables mentioned above.

Table 6. Relative Importance of the Variables According to Standardized Beta Coefficient

Variable	Coefficient
SPEAK	0.213
SCM	0.201
BOOK	0.164
COUSE	0.160
SPBSS	0.120
PHE	0.112
TMH	0.099
COMP	0.095
PATM	0.081
SVM	0.070
AGE	0.039
SEX	0.029
DESK	0.024

DISCUSSION

The results in this study reveals that, taking into account other variables, all of the variables considered are associated with mathematics achievement in Malaysia. The six most important variables influencing mathematics achievement among Malaysian eighth graders are infrequent use of language of test at home, students' self-confidence in learning mathematics, computer use, students' perception of being safe in home and parents' highest education level. The results of the present study have important implications especially for policy makers and non-government organizations involved in education.

While Malaysia faced the ongoing controversy as to whether the teaching of science and mathematics in English should be revert back to Bahasa Malaysia, the results of TIMSS study which showed a statistically significant decline in scores from the first time the study was conducted provide a relatively strong argument to those who support the idea of reverting to teaching in Bahasa Malaysia. It is in this study that showed the reverse effect of language on mathematics achievement. Those who always speak the language of test at home performed worse than those who speak less frequently and the finding is consistent with the results obtained in TIMSS 2003 and TIMSS 1999. The only difference is that students in TIMSS 1999 and TIMSS 2003 were taught in Bahasa Malaysia while students in TIMSS 2007 were taught in English. Hence we can conclude that the performance of Malaysian students in mathematics education is not affected by the language used but may be due to the fact that non-Malay students performed better than the Malay students. As mentioned earlier, students who did not speak Bahasa Malaysia regularly were predominantly Chinese and Indians while those who always speak the national language were all Malays.

This study also found that there was a positive association between level of self-confidence in learning mathematics and mathematics achievement. While achievement was highest among students at the high level of the mathematics self-confidence index, only around 28 percent of students are in this category. In fact, self-confidence levels were among the lowest in Malaysia as compared to other countries involved in TIMSS 2007. Policy makers and teachers should be aware of the low self-confidence and its effect on mathematics achievement. More strategic intervention should be implemented to help and motivate Malaysian students to be more confident in studying mathematics. Lack of confidence may lead to reduced number of students who would be able to pursue their studies in disciplines or work in jobs requiring mathematics knowledge and skills. However, it is important to note the importance of having a strong foundation in mathematics for almost all disciplines of study at the tertiary level and subsequently strong analytical skills at the work place.

Malaysians are known to have very poor reading culture. Surveys conducted in 1996 and 2005 (The Star, 16 July 2006) showed that Malaysians only read two books a year. Their preferred reading materials are mainly newspaper. Only around 3 percent read books. The result from this study also showed that only 14 percent of the students reported that they have more than 100 books in their home and that these books may mainly be school textbooks and references. Greater interest in reading should be promoted among youngsters from the early years of their life and a sustained reading habit into their adulthood. Number of books is also a proxy of students' socio-economic status (SES) which relates to the educational attainment of parents as well as affordability to purchase books and reading materials.

The government of Malaysia has taken various steps in promoting the use of computers in home such as granting tax rebates for the purchase of computers every three years, allowing employees to withdraw the Employee Providence Fund and granting personal loans to the government employees (Malaysia Budget, 2001). However, despite these measures, only 59 percent of the students come from homes that possess a computer. In its effort to encourage use of computer among school students the government has initiated a smart school project aimed at creating a schooling culture that is informed, thinking, and creative using technology. The impact of such policy has yet to be seen. Parents should be made aware of the important role of computers in improving mathematics achievement so that they should take full advantage of the government provisions enabling them to have computers in their home.

Perception of being safe in schools and parents' education are also important factors in ensuring performance of students in schools particularly in mathematics. Malaysians are very fortunate to have a government that gives such great emphasis in promoting education and hopefully the number of parents with university education will increase t and school environment will improve in the near future.

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