ASSESSING THE EFFECTS OF STUDENTS' CHARACTERISTICS AND ATTITUDES ON MATHEMATICS PERFORMANCE

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Abstract

This paper analyzes mathematics performance of grade eight students using Malaysian data drawn from Trends in International Mathematics and Science Study 2003. In particular it examines the effects of students' characteristics and attitudes towards mathematics learning on their achievement. Background information including gender of students, parents' education level and whether students speak the language of test at home are assessed in terms of their influence on mathematics score. The number of books in home, availability of study desks and computers in home are categorized as educational resources while students' attitude takes into account students' educational aspirations, their perception of being safe in school, time spent on mathematics homework, self-confidence in learning mathematics and the value students place on mathematics. Chi-squared tests and odds ratios are used to examine the associations and strength of the relationships of these factors with mathematics achievement. The results show that except for gender, language spoken at home and time spent on mathematics homework, all of the other variables have significant positive influence in classifying students to low, medium and high achievers.

Key words: *mathematics achievement, students' characteristics, educational resources, attitude, odds ratio.*

Introduction

It is well recognized that high school mathematics knowledge and competencies provide students with the analytical and problem solving skills necessary for tertiary education and beyond. Studies have shown that students who have mastered mathematical skills have better chances of employability, more career options and better prospects for promotions (Geary & Hamson, 2000; House, 1993; Nasser & Birenbaum, 2005). Hence there is considerable interest in the development of instructional approaches, curricula and educational aids and resources among others, aimed at improving mathematics teaching and learning. Of greater concern is the extent of influence these factors have on students' mathematics learning outcome as measured by their achievement on mathematics assessment.

Studies on mathematics achievement and its development are numerous focusing mainly on differences and factors which might students' achievement. For example, Papanastasiou (2000, 2002) and Kiamanesh (2004) found significant positive effect between students' attitudes towards mathematics subject and achievement in mathematics. The latter also found that self-concept, home background and teaching aids have a significant influence on mathematics achievement. Studies have also shown that gender is an important determinant of mathematics performance giving opposite effects for different data sets. While Gallagher and Kaufman (2005), Beller and Gafni (1996) and Cleary (1992) found that girls have higher mathematics score than boys in standardized mathematics

PROBLEMS
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tests, the opposite is true in a study by Alkhateeb (2001). Noor Azina (2008) investigated the effect of factors related to teachers and schools on mathematics achievement of the eighth grade students in Malaysia. Only a few of these variables were significant in explaining the variation in mathematics achievement in Malaysian students. For example it was found that students taught by female teachers, teachers' participation in developing mathematics contents and curriculum, having students with few or no limitation on instruction, teachers who implemented instructional strategies such as reviewing homework and work problems on their own had positive association with high mathematics achievement. At the same time, having students' coming from economically disadvantaged homes, have good perception of the school climate and good class attendance were also associated with high achievement in mathematics. However the study did not take students' personal characteristics into account. Hence, it is the aim of this paper to explore the relationship between students' background mathematics among eight grade students in Malaysia.

Methodology of Research

This study is a secondary analysis of the Malaysian data obtained from the student data base of the TIMSS 2003 which were available from http://timss.bc.edu/timss2003.html. The method of data collection and full description of the variables are illustrated in details by Arora et al (2005). The study was designed to provide trends in Grade 8 mathematics and science achievement in an international context involving participation of 48 countries, including Malaysia (Mullis, Martin, Gonzalez & Chrostowski, 2004). TIMSS 2003 is the third in a continuing cycle of international mathematics and science assessments conducted every four years beginning with the first study in 1995. Malaysia's first participation was in TIMSS 1999. In brief, TIMSS 2003 used a two-stage stratified cluster sample design. Firstly, schools were selected using a stratified sampling method. Then, a single mathematics classroom was selected at random from the eighth grade in sampled schools. TIMSS 2003 data for Malaysia comprise of 5314 students from 150 schools where all testing for the study was carried out at the end of the 2002 school year.

Measurement of student mathematics achievement refers to student test scores in Grade 8, which represents eight years of formal schooling. Mathematics score is calculated based on the average of five plausible values generated by TIMSS 2003 covering five content areas namely number, algebra, measurement, geometry and data. For the purpose of analysis of this study, students are grouped into three categories based on their mathematics score: high achievers refer to students who scored greater than or equal to the Malaysian average of 508, medium achievers are those who achieved at least the international average of 467 but below the Malaysian average and the low achievers are those who scored below the international average.

In this study, students' characteristics are classified into students' background, educational resources and students' attitude. Students' background include gender of students, parents' highest education level and whether students speak the language of test at home. The number of books in home, availability of study desks and computer usage are categorized as educational resources while students' attitude takes into account students' educational aspirations, their perception of being safe in school, time spent on mathematics homework, self-confidence in learning mathematics and the value students place on mathematics.

The data are examined in terms of percentage distribution. Chi-squared tests and odds ratios are used to test the association between mathematics achievements with each of the factors and the strength of the relationships, respectively.

Results of Research

Mathematics Achievement

Table1 shows that 50 percent of the students scored at least the Malaysian average of 508 indicating that the distribution of mathematics achievement is not skewed. Table 1 also shows that about 70 percent of the Malaysian students' mathematics score exceed the International average of 467 and less than one-third scored lower than the international average.

Table 1. Distribution of Mathematics Achievement.

Mathematics Achievement	Percentage
< 467 (low)	30.5
467 - < 508 (medium)	20.0
≥ 508 (high)	49.5
Total (5314)	100.0

Students' Background

Student achievement has been shown to be related to home background factors (Mullis et al, 2004). Table 2 shows the percentage distributions of students according to their background, educational resources and attitudes. Of the 5314 students participated in this study, around 58 percent of them are females compared with 42 percent males. The Chi-square statistic seems to suggest significant associations between levels of mathematics achievement and gender.

As can be observed in Table 2, more than two-thirds of the students' parents completed post-secondary education or above. However, the proportion of tertiary educated parents is still quite low for the Malaysian case. Since parents' education were found to be positively associated with student achievement in mathematics in almost all participating countries in TIMSS 2003 (Mullis et al, 2004), the relatively low percentage of highly educated parents could be one of the reasons 50 percent of Malaysian students are not in the category of high achievers.

Table 2 also shows that more than one-third of the students sometimes or never speak the language of the test at home. Since the language of the test used for TIMSS in Malaysia is Malay or Bahasa Malaysia, there is high likelihood that students who sometimes or never speak the language of test at home are those from other ethnic groups namely Chinese and Indians, other than the Malays. It should be noted that Malaysia comprises these three main ethnic groups and that the Malays make up about 58 percent of the total population. Students from ethnic Chinese and Indian families normally communicate in their own languages at home although they may study in the national schools which use Malay language as medium of instruction. It is obvious from Table 2 that the non-Malay speaking students register a much higher proportion of high achievers compared with Malay speaking students.

Table 2. Distribution of Mathematics Achievement by Background of Students.

Background of Students	Category	Total	Low	Medium	High	p-value of χ^2
Gender	1 = Girl	57.8	33.3	19.6	47.1	<0.001
	0 = Boy	42.2	28.4	20.2	51.4	
Parents' Highest Level of Education	0 = Finish Upper Secondary Level or Below	30.7	33.7	20.6	45.7	<0.001
	1 = Finish Post-Secondary and Above	69.3	18.8	18.5	62.6	
Speak Language of Test at Home	0 = Almost Always or Always	65.2	34.9	23.1	42.1	<0.001
	1 = Sometimes or Never	34.8	22.3	14.2	63.6	

Odds ratios are used to compare achievement in mathematics pair-wise among the low, me-

dium and high achievers and the results are presented in Table 3. The effects of gender differences are significant in distinguishing the high and low achievers or medium and low achievers with girls are more likely as compared to boys to be in the higher group of achievers. However, this effect diminishes when a comparison is made between the high and medium achievers.

With respect to parents' educational attainment, Table 3 indicates that all three pair-wise comparisons of high achievers to low achievers, medium to low achievers and high to medium achievers, students whose parents have at least a post-secondary education have significantly higher probability of scoring higher in mathematics than their counter parts.

Table 3 also suggests that there is no effect of use of language of test at home among low achievers (medium versus low). Nevertheless the effect becomes obvious when comparing the high achievers to low achievers and the high achievers to medium achievers.

Table 3. Odds Ratios for Comparing Mathematics Achievement by Background of Students.

Background of Students	Medium/Low		High/Low		High/Medium	
	p-value of χ^2	OR (CI)	p-value of χ^2	OR (CI)	p-value of χ^2	OR (CI)
Gender	0.018	1.208 (1.033, 1.412)	<0.001	1.279 (1.129, 1.449)	0.437	1.059 (0.916, 1.224)
Parents' Highest Level of Education	<0.001	1.608 (1.322, 1.955)	<0.001	2.453 (2.096, 2.872)	<0.001	1.526 (1.294, 1.800)
Speak Language of Test at Home	0.679	0.963 (0.805, 1.152)	<0.001	2.366 (2.066, 2.710)	<0.001	2.457 (2.095, 2.882)

Educational Resources

Students from home with extensive educational resources and study aids were found to be associated with higher student achievement in the earlier IEA studies (Mullis et al, 1999). In this study, the data in Table 4 shows that more than half of the Malaysian students are from homes with one shelf of books and below and slightly less than half of the students use computers on a regular basis. A study desk is very affordable in Malaysia and therefore it is not surprising that almost 88 percent of the students reported having a study desk at home. The effects of having lots of books, study desk and regular use of computers on mathematics achievement are clearly shown in the significantly high proportion of students scoring above the national average compared with their respective counterparts. Sixty four percent of students who use computers regularly are high achievers compared with only 35 percent of those who are not. Similarly, 63 percent of students with at least one bookcase of books are high achievers compared with 37 percent of those with a maximum of one shelf of books, and 51 percent of students with study desk at home are achievers compared with 39 percent of them who are without study desk.

Table 4. Educational Resources.

Educational Resources	Category	Total	Low	Medium	High	p-value of χ^2
Number of Books in Home	0 = One Shelf and Below	57.3	39.1	21.3	39.6	<0.001
	1 = One bookcase and Above	42.7	18.9	18.2	63.0	
Possess Study Desk in the Home	0 = No	87.6	39.7	21.2	39.1	<0.001
	1 = Yes	12.4	29.0	19.8	51.1	
Usage of Computers	0 = Irregular Use	51.6	42.4	22.3	35.4	<0.001
	1 = Regular Use	48.4	18.4	17.6	64.0	

Subsequently the result in Table 5 indicates that regular use of computer has the highest odds ratio, followed by number of books at home and possession of study desk in the home. It also suggests that without taking other factors into account, the use of computer has the highest impact on the probability of students scoring above the international average. Furthermore, students from homes with one bookcase and above are almost three times more likely to score above the international average as compared to those from homes with one shelf and below. Having study desk at home had the least impact on the probability of students scoring above the international average.

Table 5. Odds Ratio for Comparing Mathematics Achievement by Educational Resources.

Educational Resources	Medium/Low		High/Low		High/Medium	
	p-value of χ^2	OR (CI)	p-value of χ^2	OR (CI)	p-value of χ^2	OR (CI)
Number of Books in Home	<0.001	1.766 (1.497, 2.085)	<0.001	3.303 (2.887, 3.778)	<0.001	1.870 (1.617, 2.162)
Possess Study Desk in the Home	0.030	1.279 (1.024, 1.597)	<0.001	1.790 (1.488, 2.154)	0.003	1.400 (1.123, 1.744)
Usage of Computers	<0.001	1.824 (1.551, 2.146)	<0.001	4.181 (3.656, 4.781)	<0.001	2.291 (1.979, 2.654)

Students' Attitude and Motivation

Malaysian students generally have high expectations for university education. As can be observed from Table 6, nearly 65 percent of them reported that they expect to finish university. More than 77 percent of students who inspired to finish university education scored above the international average as compared to only 60 percent of students without the aspiration in this category. A significantly higher proportion of students who have high perception of being in school, high amount of time spent on mathematics homework, high self-confidence in learning mathematics and place high value on mathematics are high achievers of TIMSS compared with their respective comparative categories.

Examining the proportion of students in the category of high achievers reveals that among the variables related to attitudes, self-confidence in learning mathematics has the largest impact on achievement followed by their perception of being in school, time spent on mathematics homework and the value they place on mathematics. The proportions of high achievers by all four variables are about the same.

Table 6. Students' Attitude and Motivation.

Students' Attitude and Motivation	Category	Total	Low	Medium	High	p-value of χ^2
Students' Educational Aspirations	1 = Finish university	64.5	22.9	20.3	56.9	<0.001
	0 = Not finish university or do not know	35.5	40.4	19.5	40.1	
Student Perception of Being Safe in School	0 = Medium or Low	51.7	35.0	20.3	44.7	<0.001
	1 = High	48.3	26.1	19.6	54.3	
Time Spent on Math Homework	0 = Medium or Low	33.0	32.7	19.6	47.7	<0.001
	1 = High	67.0	25.3	20.8	53.9	
Self-Confidence in Learning Mathematics	0 = Medium or Low	38.5	40.9	23.5	35.6	<0.001
	1 = High	61.5	13.6	14.3	72.0	
Students Valuing Mathematics	0 = Medium or Low	77.9	43.6	19.4	37.0	<0.001
	1 = High	22.1	26.8	20.1	53.1	

The odds ratio shown in Table 7 shows that students with high self-confidence have the highest probability of achieving mathematics score above the national average when compared with students whose scores are below the international average. This is followed by students' educational aspirations, students valuing mathematics and student perception of being safe in school. It can be observed that there is no significant difference in the odds of students falling into the group of high achievers and medium achievers across the time spent on mathematics homework.

Table 7. Odds Ratio for Comparing Mathematics Achievement by Students' Attitude and Motivation.

Students' Attitude and Motivation	Medium/Low		High/Low		High/Medium	
	p-value of χ^2	OR (CI)	p-value of χ^2	OR (CI)	p-value of χ^2	OR (CI)
Students' Educational Aspirations	<0.001	1.841 (1.549, 2.188)	<0.001	2.505 (2.178, 2.881)	<0.001	1.361 (1.156, 1.601)
Student Perception of Being Safe in School	0.001	1.298 (1.110, 1.516)	<0.001	1.630 (1.438, 1.847)	0.002	1.256 (1.088, 1.450)
Time Spent on Math Homework	<0.001	1.368 (1.156, 1.619)	<0.001	1.457 (1.272, 1.670)	0.409	1.065 (0.917, 1.238)
Self-Confidence in Learning Mathematics	<0.001	1.829 (1.517, 2.204)	<0.001	6.070 (5.222, 7.055)	<0.001	3.319 (2.842, 3.876)
Students Valuing Mathematics	<0.001	1.687 (1.408, 2.020)	<0.001	2.339 (2.019, 2.709)	<0.001	1.387 (1.159, 1.659)

Discussion

The findings from this study indicate that students' background, educational resources and study aids as well as students' attitudes have significant influence on mathematics achievement in classifying students into low, medium and high achievers except for gender, language spoken at home and time spent on mathematics homework. Examining mathematics scores across gender suggests that girls significantly perform better than boys among the low and medium achievers while the difference is not significant among the high achievers. In addition, there is no significant difference in the odds ratio when comparing students who are medium achievers and low achievers between students who always speak the language of the test at home and those who do not while the difference is significant when comparing between the medium and high achievers with the low achievers, respectively. Furthermore, the effect of time spent on mathematics homework can only be observed in the low achievers and not between the medium and the high achievers.

The data also shows that students from well educated parents are associated with higher probability of high mathematics performance. In terms of educational aids, computer usage has the highest impact on students' mathematics score while in terms of attitude, the biggest influence comes from self-confidence in learning mathematics.

References

Alkhateeb, H. M. (2001). Gender differences in mathematics achievement among high school students in the United Arab Emirates, 1991–2000. *School Science and Mathematics*, 101(1), 5–9.

Arora, A., Barth, J., Chrostowski, S. J., Diaconu, D., Erberber, E., Foy, P., Galia, J., Gonzalez, E. J., Johansone, I., Joncas, M., Li, I., Mullis, I. V. S., Neuschmidt, O., Ramirez, M. J. & Taneva, M. (2005). *TIMSS 2003 User guide for the international database*. Boston: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Beller, M. and Gafni, N. (1996). The 1991 International Assessment of Educational Progress in Mathematics and Science: The gender differences perspective, *Journal of Educational Psychology*, 88(2), 365-377.

Cleary, T.A. (1992). Gender Difference in Aptitude and Achievement Test Scores. Paper presented at the 1991 ETS Invitational Conference on Sex Equity in Educational Opportuniy, Achievement and Testing, Princeton, New Jersey.

Gallagher A.M. and Kaufman, J.C. (2005). Integrative Conclusion in Gender Differences in Mathematics: An Integrative Psychological Approach, Gallagher and Kaufman (editors), Cambridge University Press.

Geary, D.C. & Hamson, C. O. (2000). Improving the mathematics and science achievement of American Children: Psychology's role, Education Directorate, American Psychological Association, http://www.apa.org/ed/geary.html

House, J.D. (1993). Achievement-related expectancies, academic self-concept, and mathematics achievement of academically under-prepared adolescent students, *Journal of Genetic Psychology,* 154, 61-71.

Kiamanesh, A. R. (2004). *Factors Affecting Iranian Students' Achievement in Mathematics*, Paper presented in the First IEA International Research Conference, Cyprus.

Mullis, I. V. S., Martin, M. O., Gonzalez, E. J., Gregory, K. D., Garden, R. A., O'Connor, K. M., Chrostowski, S. J. & Smith, T. A. (1999). *TIMSS 1999 International mathematics report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the eighth grades*. Boston: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Mullis, I. V. S., Martin, M. O., Gonzalez, E. J. & Chrostowski, S. J. (2004). *TIMSS 2003 International mathematics report: Findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades*. Boston: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Nasser, F. & Birenbaum, M. (2005). Modelling mathematics achievement of Jewish and Arab eight grades in Israel: The effects of learner-related variables, *Educational Research and Evaluation,* 11(3), 277-302.

Noor Azina Ismail (2008). Effects of teachers and schools on mathematics achievement, *Problems of Education*

in the 21st Century: Recent Issues in Education, Vol. 6, 103–112. Lithuania: Scientific Methodical Center.

Papanastasiou, C. (2000). School, effects of attitudes and beliefs on mathematics achievement. *Studies in Educational Evaluation*, 26, 27-42.

Papanastasiou, C. (2002). School, teaching and family influence on student attitudes toward science: Based on TIMSS data Cyprus. *Studies in Educational Evaluation*, 28, 71-86.

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