

PREDICTORS OF SCIENCE ACHIEVEMENT AMONG THE LOWER-SECONDARY SCHOOL STUDENTS IN MALAYSIA: AN ANALYSIS OF TIMSS DATA

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Abstract

This study seeks to identify several predictor variables of science achievement among the eighth graders (Form 2) in Malaysia. Using the Trends in International Math and Science Study 2003 (TIMSS) data for Malaysia, stepwise regression analyses were performed on the national data. Results indicate that (1) student's valuing science (SVS) and home educational resources (HER) are two strong predictor variables of science achievement at the student-level. These two variables account for 17.9 percent of the variation of science achievement between students within schools; (2) at the school-level, the mean of home educational resources (MHER) and teacher's emphasis on science experiment (EXPR) are two predictor variables of science achievement, and they account for 51 percent of the variation between school means science achievement; (3) the effects of HER on achievement become much stronger as an aggregate, resulting in MHER as the strongest predictor variables among the four predictors; and (4) teacher's emphasis on science experiment (EXPR) seems to be the only school-level predictor of science achievement unassociated with student-level factor in this study. Some of the recommendations include the call for schools, parents and community to work together to ensure that students have access to adequate educational materials at home, establishing community-based resource center in low-SES areas, increasing student's awareness to value science through various programs and activities, and ensuring that students are engaged in laboratory experiments in most of science lessons.

Keywords *TIMSS, science achievement, home educational resources, socio-economic status, science experiment*

Abstrak

Kajian ini bertujuan untuk mengenal pasti beberapa pembolehubah peramal kepada pencapaian sains dalam kalangan pelajar Gred 8 (Tingkatan 2) di Malaysia. Menggunakan data *Trends in International Math and Science Study* (TIMSS) untuk Malaysia, analisis regresi *stepwise* telah dilakukan kepada data kebangsaan. Keputusan menunjukkan bahawa (1) penghargaan terhadap sains (SVS) dan bahan pembelajaran di rumah (HER) merupakan dua pembolehubah peramal yang kuat di peringkat pelajar. Kedua-dua pembolehubah ini meramalkan 17.9 peratus variasi pencapaian sains dalam kalangan pelajar di sekolah yang sama; (2) di peringkat sekolah, min sumber

pembelajaran di rumah (MHER) dan penekanan guru terhadap eksperimen sains (EXPR) merupakan dua pembolehubah peramal pencapaian sains, dan kedua-duanya meramalkan 51 peratus daripada variasi min pencapaian sains antara sekolah; (3) kesan HER terhadap pencapaian menjadi lebih kuat sebagai agregat, menjadikan MHER sebagai pembolehubah peramal yang paling kuat antara keempat-empat peramal; dan (4) penekanan guru terhadap eksperimen sains merupakan satu-satunya faktor peramal yang tidak berkaitan dengan faktor di peringkat pelajar dalam kajian ini. Beberapa cadangan termasuklah perlunya sekolah, ibu bapa dan komuniti bekerja bersama untuk memastikan pelajar mempunyai akses yang mencukupi kepada bahan pembelajaran di rumah; penubuhan pusat sumber komuniti di kawasan SES rendah; meningkatkan kesedaran pelajar untuk menghargai sains melalui pelbagai program dan aktiviti; dan memastikan pelajar dilibatkan dalam eksperimen makmal dalam kebanyakan waktu pelajaran sains.

Kata kunci *TIMSS, pencapaian sains, sumber pembelajaran di rumah, status sosioekonomi, eksperimen sains.*

BACKGROUND AND RATIONALE

The growing emphasis on science and mathematics in today's world has led Malaysia to participate in the Third International Math and Science Study, now known as Trends in Math and Science Study (TIMSS). To date Malaysia has participated in four series of the study - 1999, 2003, 2007 and 2011. TIMSS is one of the most rigorous and comprehensive international studies ever conducted. Using questionnaires, video tapes, and analyses of curriculum materials, researchers gathered detailed information about the educational systems, learning experiences, and instructional practices in the participating countries. Results of the study have led to many important decisions in different parts of the world. In the USA for example, results of TIMSS had a clear impact on the Goal 2000, whereby one of the goals states 'to be the first in the world in Math and science'.

The TIMSS report however, focused mainly on international comparisons of students' achievement in mathematics and science. Even though the report revealed some relationships between students' average scores in science and some indices of students, teachers, and schools' background characteristics, much of the data gathered remained unexplored. Further analyses of the data would help the individual countries to better understand the performance of their educational systems, identifying their own strengths and weaknesses, and finding ways to improve the systems.

A study using TIMSS 1999 data by Mokshein (2002) showed that 60 percent of the variation in science achievement was attributed to school-level factors while the remaining 40 percent to student-level factors. The four selected student-level factors, namely home educational resources (HER), students gender (SEX), self-concept in science (SCONCEPT), and awareness of social implications of science (SOCAWARE) explained 13 percent of the student-level variance, while the four selected school factors explained 55 percent of the school-level variance, with school mean HER (MHER)

and school mean parent's education, MPEDU (both being SES indicators) explaining more than half (50.45 percent) of the variation in school mean scores. It is important to examine if similar results in the earlier study remain, and to explore what other variables predict students' achievement in science so that appropriate recommendations can be put forward.

TIMSS 1999 and TIMSS 2003

The trend in International Math and Science Study (TIMSS) focuses on international comparisons of educational systems and outcomes in math and science. It was first conducted in 1994-95 under the auspices of the International Association for Evaluation of Educational Achievement (IEA) and it was the largest international education study ever conducted with data from one-half million students in more than 40 nations (Martin, Mullis, et al., 2000). Four IEA studies in the area of mathematics and science preceded TIMSS - the First Mathematics Study, 1959-1967; the First Science Study, 1966-1973; the Second International Mathematics Study, 1976-1987; and the Second International Science Study, 1976-1987. The number of participating countries in TIMSS 1995, 1999 and 2003, however, differed slightly. The TIMSS 1995 was administered to the fourth, eighth, and twelfth graders in 41 countries, TIMSS 1999 in 38 countries while TIMSS 2003 in 50 countries.

In the 1999 study, Malaysia was ranked number 20 among the 38 participating countries and the average score for Malaysian students was 492, slightly above the international average (488). This placed Malaysia in the same group of scores around the mean as Italy, Lithuania, Latvia, and Thailand. In 2003, Malaysia was ranked number 22 among the 50 countries and the students' average score was 510, well-above the international average (474). However, the reports also cautioned the readers that international comparisons may not mean much when the TIMSS topics taught in schools varied from one country to another. Only about 57 percent of the TIMSS topics were covered in the Malaysian curriculum (EPRD, MOE Malaysia, 2001).

The TIMSS 1999 and 2003 reports also revealed some important patterns of association between student's achievement and some of the student, teacher and school background factors. In TIMSS 1999, there seemed to be some correlations between achievement and indices of home educational resources (HER), student's self-concept in science, student's attitudes towards science, and student's expectations for finishing school. Further analysis of the Malaysian data by Mokshein (2002) using Hierarchical Linear Modeling (HLM) technique showed that home educational resources (HER), parent's education (PEDU), and student's self-concept in science (SCONCEPT) are important factors in explaining the variation of science achievement among students within schools. The effect of HER on achievement was even greater at the school-level whereby school mean of HER (MHER) explained about 33 percent of the variability between school means achievement. The school mean of PEDU (MPEDU) explained 17 percent of variation between schools while teacher's emphasis on science experiment explained 2.5 percent of the variation. Together, both the socio-economic related factors (MHER and MPEDU) explained half of the total variation between schools.

In TIMSS 2003 international report, achievement seemed to be correlated with indices of parents' education, time spent for science homework, confidence in learning science, student's valuing science, and the availability of educational resources at home such as books, computer, and study table (Martin, Mullis, et. Al., 2004; EPRD, Ministry of Education, 2004). However, the significance of these factors on science achievement and how large is the contribution of each factor on achievement were not presented in the report. This study included four variables related to students' characteristics namely parents' highest education (PEDU), home educational resources (HER), self-confidence in science (SCONFID) and students' valuing science (SVS) at the student-level.

Several studies using hierarchical linear modeling (HLM) technique of analysis had also shown that the average of some student-level variable values within each school predicted school mean achievement (Bryk and Raudenbush, 1992; Mokshein, 2002). Using the 1982 U.S. High School and Beyond Survey data, Bryk and Raudenbush (1992) showed that the average of the students' SES values within each school (MEAN SES) was highly significantly correlated with school mean achievement and contributed to the variability between schools. They found that 69 percent of the between-school variance was accounted for by MEAN SES. Borrowing this idea and an earlier study by Mokshein (2002), school mean of home educational resources (MHER) was used as predictor of science achievement at the school-level, besides teacher's experience (YRSTCH), teacher's emphasis on conducting science experiment (EXPR), teacher's emphasis on homework (HMEWORK) and teacher's major (MAJOR).

Research Questions

The main purpose of this study is to explore some student-level and school-level variables that predict Malaysian students' achievement in science using the TIMSS 2003 data. In addition, it uses data on teachers' perception on factors they believe to be important to predict science achievement. Specifically, the study is aimed at answering the following research questions:

- (1) What are some of the student-level variables associated with student's background that predict science achievement among the lower-secondary school students?
- (2) What are some of the school-level variables associated with school environment and processes that predict science achievement?
- (3) How much do those variables account for the variation in students' science scores?
- (4) What are some of the variables at the student-level and school-level that predict students' achievement in science as perceived by the science teachers and school principals?

Hypotheses

Based on the research questions, several statistical tests were performed to test the following null hypotheses:

1. The effects of each of the selected student-level variable on achievement is zero.

$$H_0: B_1 = B_2 = B_3 = B_4 = 0; \alpha = 0.05$$

2. The effect of each of the selected school-level variable on school mean achievement is zero.

$$H_0: B_1 = B_2 = B_3 = B_4 = 0; \alpha = 0.05$$

Significance of the Study

Results of the study will hopefully help the Ministry of Education (MOE), schools, teachers, and parents to identify ways to improve students' achievement in science. This may include providing appropriate support for the students, teachers and schools, modifying the curriculum, and adapting new curriculum practices. For the government, the findings could be useful in the formulation of decisions pertaining resource allocation and improvement efforts in science education. In addition, the results may also enrich TIMSS findings.

Conceptual Model

This study employed Mokshein's (2002) conceptual model of the relationship between science achievement and student-level and school-level factors in exploring the predictor variables of science achievement. The model was earlier developed based on Hemmings's (1996) clusters of factors that had significant direct or indirect impact on senior secondary school achievement known as Tertiary Entrance Rank (TER) in Australia, with some modification. Mokshein identified three clusters of factors, namely home background factors, student personal characteristics, and school factors. The student's personal characteristics and home background factors were further grouped as student-level factors.

Findings from earlier studies (Ahmad, 1997; Ariffin, 1988; Baker and LeTendre, 2000; Blau and Duncan, 1967; Bryk and Raudenbush, 1992; Cannon and Simpson, 1983; Farkas, 2000; Heyneman and Loxley, 1982; 1983; Lareau, 1987; Posletwaite and Wiley, 1992; Marks and Ganzenboom, 2002; Martin and Mullis, 2000; Mokshein, 1996; 2002; Ratcliffe, 1992; Schebechi and Riley, 1986; and Schneider and Coleman, 1993) were taken into account in deciding the variables of interest under each cluster. The conceptual model for this study is illustrated in Figure 1.

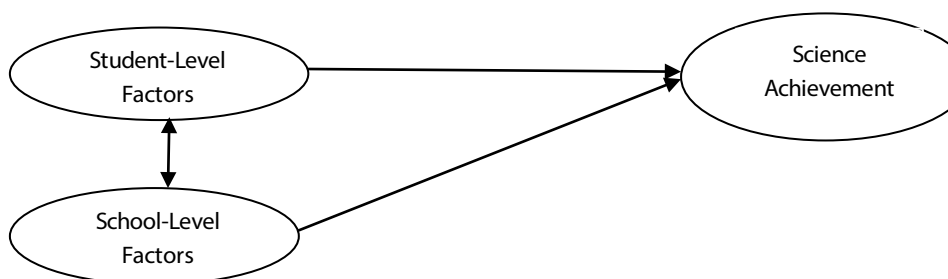


Figure 1 Conceptual Model of the Predictors of Science Achievement

In the initial model, four variables were identified at the student-level, namely parent's highest education (PEDU), self-confidence in science (SCONFID), home educational resources (HER), and student's valuing science (SVS). At the school-level, five variables were selected - teacher's major (MAJOR); teacher's experience or years been teaching (YRSTCH); teacher's emphasis on conducting experiments (EXPR) and emphasis on homework (HMEWORK); and school mean of home educational resources (MHER).

METHODOLOGY

This is a descriptive study focusing on the relationship between students' achievement in science and selected student-level factors related to home background and students' characteristics and several school-level factors related to teachers and instructions using quantitative data gathered in the TIMSS 2003. The study involved all the 2003 TIMSS participants – about 5,577 Form 2 (eighth grade) students and 150 of their science teachers from 150 schools in Malaysia. At the first sampling stage, schools were chosen at random from all secondary schools in Malaysia. Stratification by region and urbanization was used to ensure that urban and rural schools in all the 15 states were represented. A total of 28 strata were involved. The sampling for the Malaysian schools was conducted by Statistics Canada using the school-sampling frame provided by the MOE Malaysia.

Prior to sampling, schools in the sampling frame - a comprehensive national list of all eligible schools, were assigned to 28 predetermined numbers of strata. Schools were selected based on a systematic probability-proportional-to-size (PPS) technique. The probability of selection for a school was proportional to the number of eighth grade students in the school. According to the TIMSS 1999 international report, there were essentially three reasons for stratifying: (a) to produce reliable estimates for sub-national domains, (b) to improve the sampling efficiency, thereby improving the reliability of national estimates; and (c) to ensure that different parts of the population are appropriately represented in the sample.

Within each sampled school, a list of eligible classrooms was prepared for the target grade. At the second sampling stage, a single eligible classroom was randomly selected from each participating school. Since science and mathematics are core subjects in Malaysian schools, all students in the selected classrooms were involved in the study.

Apart from the analysis of TIMSS 2003 data, twenty-seven (27) science teachers and principals in six sampled schools in the states of Selangor, Malacca and Johor were involved in in-depth interviews to seek their views and opinion on important predictor variables and how they affect students' achievement. The six schools were selected from the 150 schools involved in TIMSS 2003. Selection of schools within states was not strictly random due to the unavailability of some schools during the data collection period that coincided with swine flu (H1N1) incidence. This is however acceptable since the interview data from school were used only to complement the quantitative data from TIMSS 2003 and not to determine the predictor variables of science achievement.

Instruments

The study employed three types of instruments used in the TIMSS 2003: the Achievement Test Booklets, Student Questionnaire Main Survey (SQ2), and the Science Teacher Questionnaire Main Survey (TQS2). However, variables were derived only from the Main Survey Questionnaires, not from the Achievement Test Booklets. Other than these instruments, open-ended interviews were conducted to explore teachers' and principals' professional opinion and views on important predictor variables and how they affect science achievement. The interviews were unstructured in nature and further questions were asked to probe deeper into issues.

Achievement Test

Testing was designed so that no one student took all items, which would have required more than three hours. The test consisted of science and mathematics questions assembled in eight booklets, each requiring 90 minutes to complete. Each participating student was assigned one booklet only, and the items were rotated through the booklets so that each item would be answered by a representative sample of students. For Malaysia, the tests and questionnaires that were originally prepared in English were translated into the Malay language. A series of verification checks were conducted to ensure the comparability of the translations.

About one-fourth of the items were in the free-response format, requiring students to generate and write their own answers. The rest were multiple-choice items. Correct answers to most questions were worth one point, while the free-response items were evaluated for partial credit, with each fully correct answer being awarded two points (Martin et.al., Benchmarking Technical Report, 2001). This study used students' scores available in the TIMSS 2003 data files, namely the five plausible values of the composite science scores.

Survey Questionnaires

TIMSS 2003 included a broad array of questionnaires to collect data on the educational context for student's achievement. Benchmark Coordinators and National Research Coordinators (NCRs) from participating countries, with the assistance of their

curriculum experts, provided detailed information on the organization, emphases, and content coverage of the mathematics and science curriculum. In the Student's Main Survey Questionnaire, students answered questions pertaining to their personal characteristics such as attitudes towards mathematics and science, their academic self-concept, and out-of-school activities, besides classroom activities and home background characteristics. In the Teacher's Main Survey Questionnaire, the mathematics and science teachers of the sampled students responded to questions pertaining to instructional practices, teaching emphases on topics in the TIMSS curriculum framework, professional training and education, and their views on mathematics and science. The school principals responded to questions about school staffing and resources, mathematics and science courses offerings, and teacher support. This study used raw data plus data from some derived variables in the Student's and Science Teacher's Main Survey Questionnaires available in the TIMSS 2003 data files.

DATA COLLECTION PROCEDURE

Four data files in the TIMSS 2003 were used: (a) the Student Written Assessment File (BSAMYSM2); (b) Student Background File (BSGMYSM2); (c) Science Teacher Background File (BTSMYSM2); and (d) Student-Teacher Linkage File (BSTMYSM2). Creation of a new data file for this study took place between January 2009 and April 2009. The variables were derived from the raw scores of several items in the survey questionnaires using TIMSS guidelines and scaling. Coding for each item was checked, as well as the labels and direction. Factor analysis was performed on items with similar scaling under each variable to ensure they belong to similar factor or construct. Items with factor loadings less than 0.6 were removed.

Values for the derived variables were computed and irrelevant items were deleted before the student and the teacher files were merged to create a new data file that contained science scores and the selected variables. This merging was necessary since some derived variables such as emphasis on conducting experiments require responses from both teachers and students. These processes were done mainly using SPSS for Windows. The interviews with science teachers and school principals in the six schools were conducted between July and August 2009, after some analyses of the quantitative data in TIMSS 2003 were performed and preliminary results were obtained.

Variables

Four student-level variables and five school-level variables were selected in this study. The variables were derived from the raw scores of several items in the survey questionnaires using TIMSS guidelines and scaling. Coding for each item was checked, as well as the labels and direction. Factor analysis was performed on items with similar scaling under each variable to ensure they belong to similar factor or construct. Items with factor loadings less than 0.6 were removed.

Student-Level Variables:

The four variables related to student's personal characteristics and their home backgrounds studied are as follows:

- (1) Index of Students' Self-Confidence in Learning Science (SCONFID)
- (2) Parent's Highest Level of Education (PEDU)
- (3) Students Valuing Science (SVS)
- (4) Home Educational Resources (HER)

School-Level Variables:

The five selected school-level variables tested to predict students' achievement in science are as follows:

- (1) Major (MAJOR)
- (2) Years Been Teaching (YRSTCH)
- (3) School Mean of Home Educational Resources (MHER)
- (4) Teacher Emphasis on Science Homework (HMEWORK)
- (5) Teacher Emphasis on Science Experiment (EXPR)

Details of these variables are presented in Appendix A.

Validity and Reliability of the Test

TIMSS is one of the biggest and most comprehensive international studies involving 50 countries. Instruments used in the study were carefully designed by a group of international experts in education. Through a series of efforts, countries submitted items that were reviewed by subject-matter specialists, and additional items were written to ensure that the desired science topics were covered adequately. Items were pilot-tested, results were reviewed, and new items were written and piloted (TIMSS International Science Report, 2000).

The TIMSS 2003 achievement test was designed in eight booklets that contained mathematics and science questions, with each student assigned only one booklet. Even though questions may vary from booklet to booklet, they were designed with the same level of difficulty. Since each student was administered only a fraction of the items in the test, TIMSS made use of multiple imputation or plausible values (Gonzalez, E. J., Miles, J. A., et al., 2001). A plausible value is an estimate of how the individual student would have performed on a test that included all possible items. This estimate is based on the responses to the items that were included in the test booklet that the students actually took and the performance of students with similar characteristics based on their responses to the background questionnaires.

Because of the complexity of the TIMSS instruments and data sets, raw scores for individual items in the test were not used in this study. Rather, the average of the five plausible values generated in TIMSS data files were used for the analyses. For the

independent variables, however, raw scores for the individual items from the TIMSS data files were used. The reliability coefficients computed using the SPSS for Windows (Version 17.0) for the dependent variable and some of the independent variables are presented in Table 1.

Table 1 Reliability of Some of the Variables

Variable	Alpha	Note
COMPS	0.971	From the 5 plausible values of science scores
SCONFID	0.665	Students' responses
SVS	0.846	Students' responses
EXPR	0.742	Teachers' responses and students' response

Data Analysis

The data in this study were analyzed using the SPSS for Windows version 17.0. Unimportant variables were eliminated from the equations using stepwise regression analyses. Prior to the actual regression analyses, the scatter plots, frequencies, inter-correlation matrix, and descriptive statistics of the data were explored to examine the nature of the data and multi-collinearity among variables. Stepwise regression analyses with probability of F to enter ≤ 0.05 and probability of F to remove ≤ 0.01 were then performed on the data. Variables that did not satisfy the above criteria were then removed from the equations.

Regression Models:

At the student-levels, four variables were initially selected based on results of the previous studies. The regression model is as follows:

$$\text{COMPS} = B_0 + B_1(\text{PEDU}) + B_2(\text{HER}) + B_3(\text{SVS}) + B_4(\text{SFCONFID}) + E$$

Where:

COMPS = Composite science score

PEDU = Parents' highest level of education

HER = Home educational resources

SVS = Student's valuing science, and

SFCONFID = Student's self-confidence in science

At the school-level, five variables were initially selected based on public perceptions and findings from earlier studies. The regression model is as follows:

$$\text{SCHMEAN} = B_0 + B_1(\text{MAJOR}) + B_2(\text{YRSTCH}) + B_3(\text{MHHER}) + B_4(\text{EXPR}) + B_5(\text{HMEWORK}) + E$$

Where:

SCHMEAN = School mean of scores or mean of COMPS

MAJOR = Teacher's major (science or other)

YRSTCH= Teachers' teaching experience (years)

MHER = School mean of students' home educational resources,

EXPR = Teacher's emphasis on science experiment

HMEWORK = Teacher's emphasis on homework.

This model is quite similar to the Hierarchical Linear Model (HLM) analysis used in Mokhsein's study in 2002. However, all analyses in this study were done using Statistical Package for Social Science (SPSS) software due to the unavailability of HLM software in the workplace and the analyses at student-level and school-level were done separately.

FINDINGS AND DISCUSSIONS

This study involves a number of student-level and school-level variables. The final analysis involved 5314 students from 150 schools. Missing data were replaced with group mean. The descriptive statistics for the dependent and independent variables are presented in Table 2. The mean score for the Malaysian students is 509.24 with a standard deviation of 63.42. The highest score is 708.41 and the lowest is 261.72. Findings of this study are presented in the following sections.

Inter-Correlation between Variables

Bivariate analysis shows that science achievement is significantly correlated with all the four student-level variables and two of the school-level variables. Achievement is moderately correlated with home educational resources, parent's education, and student's valuing science ($r = \text{around } 0.3$), but weakly correlated with self-confidence in science ($r = 0.01$). At the school-level, correlation coefficients vary from low to high. School mean achievement, in turn is strongly correlated with mean of home educational resources ($r = 0.69$) and moderately correlated with teacher emphasis on science experiment ($r = 0.33$), but weakly correlated with years of teaching ($r = 0.09$) and teacher's major (0.15). Inter-correlation between independent variables at both student and school levels are generally low with correlation coefficients ranging between 0.04 to 0.2.

Table 2 Descriptive Statistics of the Variables in the Study

 Student-Level Factors:

Variable Name	N	Mean	SD	Minimum	Maximum
COMPS	5314	509.24	63.42	261.72	708.41
PEDU	5314	3.18	1.16	1.00	5.00
HER	5314	1.71	0.46	1.00	3.00
SVS	5314	1.76	0.52	1.00	4.00
SFCONFID	5314	1.90	0.37	1.00	3.00

 School-Level Factors

Variable Name	N	Mean	SD	Minimum	Maximum
SCHMEAN	150	508.88	48.74	400.19	628.32
YRSTCH	150	11.24	8.35	1.00	33.00
MAJOR	150	1.43	0.49	1.00	2.00
EXPR	150	2.11	0.37	1.31	3.39
HMEWORK	150	1.92	0.92	1.00	3.00
MHER	150	1.71	0.21	1.09	2.03

Predictor Variables at the Student-Level

Four student-level variables were initially selected to predict students' achievement in science as reflected by the following equation:

$$\text{COMPS} = B_0 + B_1(\text{PEDU}) + B_2(\text{HER}) + B_3(\text{SVS}) + B_4(\text{SFCONFID}) + E$$

Where:

COMPS = Composite science score

PEDU = Parents' highest level of education

HER = Home educational resources

SVS = Student's valuing science, and

SFCONFID = Student's self-confidence in science

Results of stepwise multiple linear regression analysis performed on the data show that all the four student-level variables, namely student's valuing science (SVS), home educational resources (HER), parent's education (PEDU), and self-confidence in science (SFCONFID) are found to be predictors of student's science achievement. However, SFCONFID and PEDU were removed from the final model due to their small contribution. The contribution of PEDU on achievement was merely 2.3 percent, while for SCONFID about 0.2 percent. Thus, only two variables, namely SVS and HER were kept in the final stepwise regression model. The unique contribution of SVS on achievement was 10.2 percent and HER 7.6 percent, and together the two

variables predict 17.9 percent to the variation in achievement. Details of the results are presented in Table 3.

Table 3 Student-Level and School-Level Factors that Predict Science Achievement

Student-Level Factors:						
Variable	B	Beta	Adj R Square	R Square Change	F Change	Sig. F
COMPC	577.93					
SVS	-38.70	-0.27	0.102	0.102	605.76	0.00
HER	-30.79	-0.22	0.179	0.076	439.89	0.00
School-Level Factors:						
Variable	B	Beta	Adj R Square	R Square Change	F Change	Sig. F
SCHMEAN	811.26					
MHER	-149.32	-0.65	0.47	0.47	133.11	0.00
EXPR	-27.76	-0.21	0.51	0.04	13.01	0.00

Notes: (1) Significance level at 0.05, (2) The negative values show the direction associated with the scaling.

In general, the index of SVS is high with 98.9 percent of the students agree that science is valuable. About 64 percent (63.6 percent) of the students responded ‘I agree a lot’ to all the items on the value of science, while another 35.3 percent of students responded ‘I agree a little’ to the items. In contrary, parent’s education is generally low with only 11 percent of student’s having either parents finished university education and about 20 percent finished vocational or technical post-secondary education.

Further analyses of HER show that majority of the students (89.2 percent) have had used computers either at home, in school, at friends’ houses, or at the internet cafe. In terms of computer usage, however, 71.4 percent of those who ever used computers used it for searching information, 56.4 percent for data processing and analysis, while only 49.9 percent use for preparing school report.

Analyses also show that more than half of the students (57 percent) have computers at home. Almost all students (98.5 percent) have dictionary at home and majority (87.6 percent) possess a study table. About 40 percent of them have only one shelf of books (11-25 books) at home, 28.2 percent have one bookcase (26-100 books), and 14.6 percent possess more than 100 books at home. The percentage of students who have computer and all the three study aids at home is 29.3 percent.

Predictor Variables at the School-Level

At the school-level analysis, five variables were initially selected to predict school mean achievement in science. The relationships among variables are reflected in the following equation:

$$\text{SCHMEAN} = B_0 + B_1(\text{MAJOR}) + B_2(\text{YRSTCH}) + B_3(\text{MHER}) + B_4(\text{EXPR}) + B_5(\text{HMEWORK}) + E$$

Where:

SCHMEAN = School mean of scores

YRSTCH= Teachers' teaching experience (years)

MHER = School mean of students' home educational resources,

EXPR = Teacher's emphasis on science experiment

HMEWORK = Teacher's emphasis on homework

Three variables, namely mean of home educational resources (MHER), mean of teacher's emphasis on science experiment (EXPR), and teacher's major (MAJOR) were found to be predictors of school mean science achievement. However, MAJOR was excluded from the final stepwise regression model due to its small contribution.

Results of stepwise multiple linear regression analysis performed on the data show that mean of home educational resources (MHER) and teacher's emphasis on conducting experiment (EXPR) are found to be two strong predictors of student's science achievement at the school level. MHER contributes 47.0 percent to the variation in science achievement between schools, whereas EXPR contributes 4.0 percent to the variation. Together, these two variables account for 51.0 percent of the total variation in science achievement between schools. Details of the results are presented in Table 5.

In general, the index of mean of home educational resources (MHER) is moderate (average of 1.74 in a three-point scale of 1-3, where 1 means books greater or equal 100 and all three study aids are available, 3 means books less than 25 and no aids at home, and 2 for all other possible combinations). Similar observation is found for teachers' emphasis on science experiment, with the average of 2.22 in a four point scale of 1-4 (where 1 means in every, or almost every lesson, 2 means half of the lessons, 3 means some of the lessons and 4 means never).

Variation in Students' Science Score Attributed to Student-Level and School-Level Variables

As shown in Table 3, the two variables, namely SVS and HER account for 17.9 percent of the variation in science achievement, with SVS accounts for 10.2 percent of the variation and HER accounts for 7.6 percent. Together SVS and HER predict about 17.9 percent of the variation in science achievement. The contribution of PEDU (2.3 percent) and SFCONFID (0.2 percent) is too small. Thus, SFCONFID and PEDU were excluded from the final model. These findings are quite similar to those of Mokshein's (2002) study that showed the significance of home educational resources (HER), parent's education (PEDU), self-concepts in science (SCONCEPT), attitude (ATTITUDE), and awareness of social implications of science (SOCAWARE) in explaining the variation of scores within schools. In the Mokshein's (2002) study, however, the six variables selected explained only about 13 percent of the variation in science achievement, with the contribution of PEDU was 0.27 percent and HER 1.46 percent. The combined contribution of HER and PEDU was only 1.73 percent. The

contribution of these two variables is about six times higher in the current study, which is 9.9 percent.

The variable self-concept in science (SCONCEPT) in Mokshein's (2002) study has several similar items as self-confidence in science (SFCONFID) in the present study, but they are not exactly similar variables. The contribution of SCONCEPT (5.65 percent) was quite large in the previous study, so was the contribution of social awareness of the implication of science or SOCAWARE (3.4 percent). In this present study, however, a new variable that was not explored before, student's valuing science (SVS) has been found to be a strong predictor of science achievement that contributes to 10.2 percent of the variation in science achievement within schools.

As shown in Table 3, the two variables, namely mean of home educational resources (MHER) and teacher's emphasis on science experiment (EXPR) account for 51.0 percent of the variation in school mean science achievement, with MHER alone accounts for 47 percent of the variation and EXPR accounts for 4.0 percent. The contribution of MAJOR is small (1.4 percent), and thus, MAJOR was excluded from the final model. This again confirms the findings of Mokshein's (2002) on the significance of means of home educational resources (MHER) in explaining the variation between school means. In the Mokshein's (2002) earlier study, MHER explains 33.7 percent of the school means variation, whereas in this study, the contribution of MHER is much higher (47.0 percent). The effect of means of parent's education (MPEDU), however, is not significant in this study, while in the previous study the contribution was quite large (17.08 percent).

Predictor Variables as Perceived by Science Teachers

Interviews conducted with six (6) school principals and twenty-one (21) science teachers show that teachers' perception on the important factors that predict science achievement are quite similar with the quantitative analysis done earlier using regression models. They perceived teacher's emphasis on science experiment (EXPR), parents' education (PEDU), teacher's emphasis on science homework (HMEWORK), students' attitudes (ATTITUDE), teacher's teaching approaches (APPROACH), parents' involvement in their children's learning (P_INVOLVE), students' foundations in science (FOUNDATION) and home educational resources (HER) as important factors that determine variables.

Results of the analysis of the interview data support the earlier results obtained from the regression analysis. Results of these quantitative and qualitative analyses are consistent on the importance of PEDU, EXPR, and HER. What differs is the order of importance of these variables that teachers placed. While the regression analyses suggest that student's valuing science (SVS) and HER as more potent factors at the student-level and school mean HER (MHER) and EXPR being the most potent factors at the school-level, teachers perceive EXPR, PEDU, HMEWORK and ATTITUDE as more important than HER.

However, there are also some disagreements in these two types of data. Teacher's emphasis on homework (HMEWORK), which was ranked third by teachers, was found not to be significant in the regression analysis. Similarly, student's valuing

science (SVS), a potent variable in the regression analysis, did not emerge in the interview with teachers. Rather, they used the term attitude (ATTITUDE) which could have meant quite the same to them. Several other factors which were not in the regression models were also highlighted by teachers such as parents' involvement (P_INVOLVE), teacher teaching approaches (APPROACH), students' foundations in science (FOUNDATION), and SES. To certain extent, however, SES is embedded in PEDU and HER in the quantitative data. Results of the interview are summarized in Table 4.

Table 4 Important Variables that Predict Achievement Perceived by Teachers and Principals

No.	Variable	No. of Respondents	Ways in which Variable Influence Achievement
1	EXPR	22	Reinforce understanding of theories learned if properly conducted and students are involved in discussions/ conclusions.
2	PEDU	20	Pay more attention to children's learning, role modeling, provide coaching, set high expectations, monitor homework, provide better environment, learning facilities.
3	HMEWORK	19	Reinforce understanding, especially if solutions are discussed.
*4	ATTITUDE	18	Determines efforts to learn, initiative to do homework, attend tuition/ extra classes.
*5	APPROACH	14	Using different approaches for different classes/ groups of students – better facilitate students' understanding.
6	HER	13	Create more opportunities for learning from home.
*7	P_INVOLVE	11	Parental supervision and monitoring of students activities at home including doing homework helps learning.
*7	FOUNDATION	11	Basic knowledge and skills from earlier grades serve as pre-requisites for learning at secondary level of education.
8	SES	7	Provides chances for wider exposure about life opportunities. Students' exposure to different educational paths and career opportunities motivates them to learn.

Notes: (1) ATTITUDE = Student's attitudes, FOUNDATION = Student's foundations of basic concepts and skills in science, P_INVOLVE = Parents' involvement in children's learning. (2) * Variables not in the regression models in the study.

CONCLUSIONS AND RECOMMENDATIONS

Several conclusions can be drawn based on the findings of this study. First, student's valuing science (SVS) and home educational resources (HER) are two strong predictor variables of science achievement at the student-level. These two variables account for about 17.9 percent of the variation of science achievement between students within schools. The unique contribution of SVS is 10.2 percent while for HER was 7.6 percent. These results are consistent with findings by Mokshsein (2002) using TIMSS 1999 data and HLM analyses whereby home educational resources (HER) and student's awareness of implication of science (SOCAWARE) were found to contribute significantly towards science achievement. These results also support findings of earlier studies on achievement and SES (Blau & Duncan, 1967; Lareau, 1987; Schneider & Coleman, 1993; Mokshsein, 1996; 2002) and attitudes (Ariffin, 1998; and Goh, 1998; and Mokshsein, 2002).

Second, mean of home educational resources (MHER) and teacher's emphasis on science experiment (EXPR) are two school-level predictors of science achievement. Together, these two variables account for 51.0 percent of the variation between school means science achievement. MHER alone accounts for 47 percent of the variation in school means science achievement, while EXPR accounts for 4.0 percent.

Third, the effects of HER on achievement become much stronger as an aggregate, resulting in MHER as the strongest predictor variable among the four predictors. At the student-level, HER accounts for 10.2 percent of the variation in science achievement between students, but the mean of HER (MHER) accounts for 47 percent of variation between school means of science achievement. This result is consistent with findings by Mokshsein (2002) using the TIMSS 199 data. This also parallels Bryk and Raudenbush's (1992) finding using HLM analysis that MEAN SES explains a large proportion of the between-school variation among the high school students' math achievement (69%) in the United States.

Fourth, teacher's emphasis on science experiment (EXPR) seems to be the only school-level predictor of science achievement unassociated with student-level factor. Fifth, all the four predictor variables of science achievement in the study – SVS, HER, MHER and EXPR are possible to be manipulated. Parents can work harder to provide more home educational resources, school can work out ways to increase teacher's emphasis on science experiments, and together schools and parents can collaborate to increase students' valuing science. Sixth, results from both the qualitative and quantitative analysis, to a large extent arrive at common predictor variables of science achievement. They also suggest that schools and parents have to work together to improve students' achievement.

Several recommendations can be made based on the conclusions of the study. First, looking at the strength and importance of home educational resources (HER) in predicting science achievement, schools, parents and community should work together to ensure that students have access to adequate educational materials at home. This can be done through several ways. Second, since not all parents can afford to provide sufficient resources for their children, schools should find ways to ensure that students have access to sufficient science-related materials and resources, including

computers. This include giving students homework assignments that require them to search for materials outside of their textbooks, or directing student to specific articles, documentary films, and observations of events or phenomena around them.

Third, since students valuing science (SVS) is another strong predictor of science achievement, efforts should be geared to increase student's awareness to value science. This may include developing or strengthening existing programs such as science awareness week, science exhibition, and science camp that involve active participation of the students. Schools may also involve parents and local communities in some of these activities.

Fourth, since teachers' emphasis on conducting science experiments (EXPR) is another potent predictor of science achievement, school principals or administrators must ensure that students are engaged in laboratory experiments in most of science lessons. This finding supports the emphasis on conducting experiments advocated in the national science curriculum. Science experiments are important for the acquisition of science concepts, ideas, and principles. However, attention should be given to the proper implementation of the curriculum. Teachers should be able to select important experiments for each topic, guide students to conduct experiments correctly, and optimize the experiment-related discussions to develop students' process skills. Periodic discussions at the school and district levels on how to carry out these processes affectively can be done through the subject panels at both levels.

Fifth, schools should learn from other schools with high means achievement in science - what these schools have in common. Even though school means of HER and EXPR predict 41 percent of the variation between schools, another half of the proportion of the between-school variance is still left unpredicted by these two variables. Thus, it may be worthwhile to look at the specific programs in science or social processes in the form of norms or current practices to promote student's learning in excellent schools. These may include emphasis on laboratory work, the scheduling of science laboratories, extra classes for science, science study groups, science monthly test and formative assessments, the reward and punishment system, and specific teaching strategies to promote students' interest and understanding in science.

Sixth, the main effects of HER on school mean achievement in this study do not address interaction effects between HER and other variables. Thus, future studies should also focus on the specific social processes on how HER and other SES-related variables suggested by the interview data influence school mean achievement. These may include pressure that parents place on teachers and their children for academic performance, the extent of parents' responsiveness to teachers' requests, and the precise ways in which parents influence school program through the parent-teacher association (PTA) or informal contacts with schools. Thus, qualitative studies focusing on these processes would help to complement the findings of the current study.

In conclusion, this study highlights several new important findings on the predictor variables of science achievement in Malaysia, which may also be useful to other nations of the world.

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APPENDIX A

Variables in the Study

Four student-level variables and four school-level variables were selected in this study. The variables were derived from the raw scores of several items in the survey questionnaires using TIMSS guidelines and scaling. Coding for each item was checked, as well as the labels and direction. Factor analysis was performed on items with similar scaling under each variable to ensure they belong to similar factor or construct. Items with factor loadings less than 0.6 were removed.

Student-Level Variables:

The four variables related to student's personal characteristics and their home backgrounds studied are as follows:

1. *Index of Students' Self-Confidence in Learning Science (SCONFID)*: The index was computed based on average of students' responses to the following questions regarding science:
 - I usually do well in science
 - Science is more difficult for me than for many of my classmates (Reversed)
 - Science is not one of my strengths
 - I learn things quickly in science

Responses for each item were coded on a 4-point Likert scale of 1) Agree a lot, 2) Agree a little, 3) Disagree a little, 4) Disagree a lot. The averages were then coded as follows:

- 1 = High: Average is less than or equal to 2.
- 2 = Medium: Average is greater than 2 and less than 3.
- 3 = Low: Average is greater than or equal to 3.

2. *Parent's Highest Level of Education (PEDU)*: This derived variable was computed from students' response to the following two separate questions:

- What is the highest level of education completed by your mother (or stepmother or female guardian)?
- What is the highest level of education completed by your father (or stepfather or male guardian)?

Missing values were coded 9. In cases where value for one parent was missing, the value of the other parent was used. The international version of response categories for SQ2_6A and B were coded in 1-8 scales. For the derived variable PEDU, the education categories were combined into five reporting categories which were computed as follows:

1. Finish University or Equivalent or Higher (original codes 7, 8)
 2. Finish Post-secondary Vocational/Technical Education but not University original codes 5, 6)
 3. Finish Upper Secondary Schooling (original code 4)
 4. Finish Lower secondary Schooling (original code 3)
 5. No More than Primary Schooling (original codes 1, 2)
3. *Students Valuing Science (SVS)*: The index was computed from students' responses to the following seven questions regarding science on a 4-point Likert scale of 1) Agree a lot, 2) Agree a little, 3) Disagree a little, 4) Disagree a lot :
- I would like to take more science in school (SQ2_11b);
 - I enjoy learning science (SQ2_11d);
 - I think learning science will help me in my daily life (SQ2_12a);
 - I need science to learn other school subjects (SQ2_12b);
 - I need to do well in science to get into the university of my choice (SQ2_12c);
 - I would like a job that involved using science (SQ2_12d);
 - I need to do well in science to get the job I want (SQ2_12e).

Index was based on the average of responses to the above statements and has three categories:

- 1 = High: Average is less than or equal to 2.
- 2 = Medium: Average is greater than 2 and less than 3.
- 3 = Low: Average is greater than or equal to 3.

4. *Home Educational Resources (HER)*: This variable was derived based on four items related to availability of home educational resources:
 - How many books are there in your home? [1 = none or very few (0-10 books), 2 = enough to fill one shelf (11-25 books), 3 = enough to fill one bookcase (26-100 books), 4 = enough to fill two book cases (101-200 books), 5 = enough to fill three bookcases or more (more than 200 books)].
 - Do you have these study aids at home – computer, dictionary, and study desk/table for your own use? [1 = Yes, 2 = No]

This derived variable was coded as follows:

1. Books ≥ 3 and all three study aids are available.
2. All other possible combinations.
3. Books < 3 and all three study aids are unavailable.

School-Level Variables:

The five selected school-level variables tested to predict students' achievement in science are as follows:

1. *Major (MAJOR)*: This variable was based on a single item on whether or not the science was a science major [1 = Yes, 2 = No].
2. *Years Been Teaching (YRSTCH)*: This variable was based on a single item on how long the individual science teacher has been teaching in years.
3. *School Mean of Home Educational Resources (MHER)*: This was the individual school average of students' home educational resources computed in student-level analysis. Original codes for HER were in 1-3 scales.
4. *Teacher Emphasis on Science Homework (HMEWORK)*: The index is computed from the teachers' responses to the following three question(s) regarding science homework:
 - Do you assign science homework to the TIMSS class? (YES/NO)(TQS2_27).
 - How often do you usually assign science homework to the TIMSS class? (TQS2_28) [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lesson].
 - When you assign science homework to the TIMSS class, about how many minutes do you usually assign? (Consider the time it would take an average student in your class.)(TQS2_29) [1 = Fewer than 15 minutes, 2 = 15-30 minutes, 3 = 31-60 minutes, 4 = 61-90 minutes, 5 = More than 90 minutes].

This derived variable was coded into three categories according to the following definitions:

1 = High: TQS2_27 = code 1 AND TQS2_28 = code 1 or 2 AND TQS2_29 = code greater than or equal to 3.

2 = Low: TQS2_27 = code 2 OR TQS2_27 = code 1 AND TQS2_28 = code 2 or 3 AND TQS2_29 = code 1 or 2.

3 = Medium: All other combinations.

5. *Teacher Emphasis on Science Experiment (EXPR)*: The index is computed from the average of teachers' responses to the following three question(s) regarding science homework:
 - How often do you demonstrate science experiment to your students? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
 - How often do you involve students in developing science hypothesis? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].

- How often do you involve students in planning for a science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
- How often do you ask students to conduct science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
- How often do you ask students to work in small group to conduct science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
- How often do you ask students to write explanations in a science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never] and students' responses on the following items:
- How often does your teacher do demonstration of science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
- How often are you involved developing science hypothesis? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
- How often are you involved planning for a science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
- How often are you involved conducting science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
- How often do you work in small group to conduct science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].
- How often are you involved in writing explanations in a science experiment? [1 = Every or almost every lesson, 2 = About half the lessons, 3 = Some lessons, 4 = Never].