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A MULTILEVEL STUDY ON TRENDS IN MALAYSIAN SECONDARY SCHOOL STUDENTS' SCIENCE ATTITUDE: EVIDENCE FROM TIMSS 2011

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ABSTRACT

The aim of this study was to examine the students' attitudes towards science achievement among eight grade students. The data used in this study were obtained from Malaysian eighth graders who participated in TIMSS 2011. The approach used in this study involves secondary data analysis. Secondary data analysis involves further analysis of an existing dataset with the aim of addressing a research question distinct from that for which the dataset was originally collected and generating novel interpretations and conclusions. A multilevel modeling was used to analyze the data. Multilevel modeling is a generalization of regression methods, and as such can be used for a variety of purposes, including prediction, data reduction, and causal inference from experiments and observational studies. Findings of this study found that certain demographic factors do play a role in determining the students' interest on science.

Keywords: Attitudes, Achievement, Science, Education, Secondary data analysis, TIMSS.

Contribution/ Originality

This article presents the results of a multilevel modelling of the secondary data on TIMSS 2011. Beside, this research was designed to provide trends in eighth-grade science achievement in Malaysia, particularly with regard to home, school and classroom factors. These studies also offer the opportunity to relate the teaching and learning context to student achievement.

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1. INTRODUCTION

The educational system of Malaysia is highly centralized due to the small size of the country. The Ministry of Education (MOE) is responsible for the enforcement of educational laws. The Malaysian Education System at school level under the category of government education institutions consists of Pre-school Education (aged four to six); Primary Education (six years of schooling); Secondary Education (consist of lower and upper secondary education); and Post-Secondary Education (education for individuals who have completed lower and upper secondary education but not higher education).

The teaching and learning process is a complex event, and it is influenced by many factors directly and indirectly (Mohammadpour, 2012). Students' attitudes and background factors and play an important role in the teaching and learning process of science. Those factors can affect students' progress and interest within the subject and as result students' achievements and learning. The results from the Third International Mathematics and Science Study (TIMSS), give a great opportunity for researchers to analyze the effect of students' attitudes and background factors on science achievement test scores.

Since TIMSS 1999 till TIMSS 2011 study was undertaken with the support of the Ministry of Education (MOE) for the primary purpose of comparing the Malaysia educational system to the educational systems of other countries. Before the participation of Malaysia in the IEA studies, the common belief was that the Malaysia educational system was in the good impression. This belief accounting the teachers and the parents towards students' behavior, the students' study habits, as well as the cooperation between the school and home. Thus, sciences learning and students' performance in sciences receive considerable attention from teachers, parents and communities. So overall, people in Malaysia thought that the educational system in Malaysia worked very effectively. However, the TIMSS as well as other IEA studies came to drastically change these kinds of beliefs.

Numerous research have been undertaken to investigate trends in sciences achievement and the factors influencing sciences learning and performance (Webster and Fisher, 2000; Alexandros *et al.*, 2006; Howie, 2006; Chen *et al.*, 2012). The purpose of this study was to identify the background factors that influence sciences achievement and to estimate the strength of their effects on students in Malaysia. Participating students were in the eighth grade in the TIMSS 2011. Determining significant predicting factors may help educators better understand and bridge the achievement gap among schools. Between-school variance in achievement may be attributed to some classroom-level variables which could be affected by educational policies.

2. FACTORS INFLUENCING ACHIEVEMENT IN TIMSS

In this literature review, most of the variables to be monitored and reviewed on spontaneity of previous findings. However, the literature also contains a number of studies investigating the science achievement in more detail. Alexandros *et al.* (2006) conducted a study designed to examine the relationship between self-esteem and attitudes towards science achievement based on TIMSS 1999 in Cyprus. In this study, the samples involved are grade 8 students aged 13 years from 61 schools took part. Factor analysis method is used to categorize the questions into several factors.

The study found that there was a significant relationship between self-esteem and attitudes with science achievement of students. Although self-esteem and attitudes are positive for the majority of students, but does not mean it resembles the performance of the TIMSS test. Many researchers (House, 2000) advocated that self-belief and attitude is an important factor in determining student achievement. Further research is needed to identify how self-esteem and attitudes can be linked to other findings. In addition, further studies are suggested to use qualitative methods approach to explore important aspects in more detail on that can affect student achievement in science education.

Researchers such as Chen *et al.* (2012) investigated the relationship between family resources, school climate, student learning, achievement and attitudes towards science based on TIMSS 2003 in Taiwan. The study involved a sample of 5074 students (2576 boys and 2498 girls) grade 8 involved in TIMSS 2003 test in Taiwan. In addition, SEM (Structural Equation Modeling) is used to test the model and to find the relationship among the factors. As a result, family resource factors and attitudes show a positive relationship to science achievement. However, the relationship between the school and the learning environment of students showed a negative effect on students' science achievement. Next, they were keen to investigate the relationship between socio-environmental factors and learning outcomes for knowing the characteristics of the actual context.

Researchers like Ismail and Awang (2008) made a study which aims to examine the differences in mathematics achievement among students who participated in the 1999 TIMSS-school Malaysia.Schools selected using stratified sampling method. Then, a math class randomly selected from the total sample of schools. There are 150 schools in Malaysia involved in this study with a total of 5577 students. Researchers have chosen approach Secondary Data Analysis (Secondary Data Analysis) using grade 8 TIMSS 1999 data in Malaysia as research methods. Further, some variables such as school, home, and socio-economic demographics were used to compare the mean math scores of students involved. The data analyzed show that there is significant influence of gender, language spoken at home, the expected level of education, family background, educational resources and assistance at home with the level of student achievement in mathematics. Howie (2006) reported that South African student performance in TIMSS 1999 test. He seeks to investigate the relationship between factors at the school, classroom, and students with an impact on students' math performance of South Africa. For sample selection, there are two levels of stratified cluster sample of 225 schools were randomly selected and stratified by region, type of education (public or private) and the medium of instruction (English and African). One class was randomly selected in each school. Tests and questionnaires were administered by the Human Sciences Research Council (Human Sciences Research Council), based in Pretoria, South Africa to more than 9,000 students. Questionnaires were given to 200 school principals and 400 teachers of mathematics and science at grade 8. After data cleaning is done only 194 schools and 8,146 students were used as sample data in the data analysis. In this study, data from testing book, student questionnaires, teacher questionnaires and school questionnaires were analyzed using PLS (Partial Least Square) and multi-level analysis. The study found that students are more likely to achieve higher scores in mathematics when students have the English proficiency better. In addition, the school location (rural or urban), basic amenities and resources also play an important role when seen in the achievement of students in rural schools do not achieve high scores in math. Then, the teacher factors also have an impact on student achievement. However, it is difficult to determine whether factors such as lack of teachers teaching experience, knowledge and training content may impact on student achievement. Therefore, further investigation of teacher beliefs and achievement required.

Several studies in the literature that stated not only study the performance of a country's science but also to investigate the factors for the achievement of both mathematics and science achievement. Webster and Fisher (2000) made a study which aims to address the changes in achievement in science and mathematics education in urban and rural areas of Australia. In addition, researchers also look to the school resource availability factor in urban and rural areas, taking into account variables such as students' attitudes towards science and mathematics and career aspirations of these students. In Australia, a total of 12,852 eight-grade students are required to sit for tests of mathematics and science as well as complete TIMSS questionnaires. Data was analyzed using a multi-level model. The findings tell that student achievement in mathematics and science in rural schools is lower than urban schools but the difference is small. Moreover, further research should detail the location difference factors of urban and rural schools. It must take into account the categories of locations such as schools in remote areas, semi-rural, suburban and inner-city because of these locations have specific characteristics.

Moreover, the researcher aim of this study was to examine the students' attitudes towards science achievement among eight grade students. Through this study, is expected to help students understand and cultivate a positive attitude towards science subjects themselves to strengthen interest in science. While science teachers are able to manipulate this study as a guide to help them improve their teaching towards making science subjects more interesting and not boring as well as enhancing students' understanding and mastery of science concepts. Therefore, this study focusing on the students' attitudes towards learning of science and how these attitudes are influenced by their background variables, which include gender, computer usage, parental concern, perception toward school and types of feeder school.

3. METHODS

This paper introduces the field of secondary data analysis. It begins by considering what it is that we mean by secondary data analysis, before describing the type of data that might lend itself to secondary analysis and the ways in which the approach has developed as a research tool in social and educational research. Hakim (1982) stated that Secondary analysis is any further analysis of an existing dataset which presents interpretations, conclusions or knowledge additional to, or different from, those presented in first report on the inquiry as a whole and its main results. This research was designed to provide trends in eighth-grade science achievement in an international context involving the participation of 45 countries, including Malaysia. This paper uses data drawn from TIMSS 2011, which involved Malaysian pupils who participated in the study in which all testing was carried out at the end of the school year. The sample design is discussed in detail in the TIMSS Technical Report. In brief, TIMSS 2011 used a two-stage stratified cluster sample design. Sample size is a key issue in multilevel modeling, because there is more than one sample size

(Mohammadpour, 2012). The estimated parameters are influenced by both lower and higher levels sample size; however, the higher level sample size is much more important than that of the lower level (Snijders and Bosker, 1999; Maas and Hox, 2004; Hox, 2009). Firstly, schools were selected using a stratified sampling method. Then, a single science classroom was selected at random from the eighth grade in sampled schools. There were 180 schools in Malaysia involved in this study with a total of 5,722 students. The sample size of this study at both the student and school levels were large and met the criterion suggested in the literature (Hox, 2009).

Measurement of student science achievement refers to student test scores in Grade 8, which represents eight years of formal schooling. The science test representing a range of science topics and skills in the four content areas which is biology, chemistry, physics and earth science. TIMSS data are hierarchy structured, which requires a statistical technique that takes the hierarchy structure into account. The data for this study consist of two levels: student as level-1 and the combination of the classroom and school (because only one classroom per school was selected in the TIMSS sampling design) as level-2. SPSS 18.0 was used for analysis of the data. The full maximum likelihood (Kreeft and Leeuw, 1998) was used to estimate the parameters which translate to the assumption that the sample size must be sufficient large.

Multilevel modeling methods become famous and leading for the hierarchical analysis of a variety of problems. A hierarchy consists of lower-level observations nested within higher level (Kreeft and Leeuw, 1998). The advantage of using multilevel models is their ability to separately estimate the predictive effects of an individual predictor and its group-level mean, which are sometimes interpreted as "direct" and "contextual" effects of the predictor (Gelman, 2006). Furthermore, statistical analysis could test multilevel hypotheses simultaneously at any level of the hierarchy.

4. RESULTS

The overall average science achievement obtained from this data set is 426, placing Malaysia as one of the 23 countries with an average achievement score that was significantly below the international average of 470 of the 45 participating countries (Mullis *et al.*, 2000).The achievement data was accompanied by extensive questionnaire data about the students' attitudes towards science as well as their home and school background information. Several variables pertaining to individual student's characteristics were included in the study, namely gender, computer, parent, school background by different location of school (urban, sub-urban, rural). Information on home background consisted of parental concern about the children's study in the home such as monitoring, chatting, guiding and checking their children's homework. Moreover, the information from student's level of computer usage and perception toward their school also important in this research.

In this study, multilevel modeling is used to treat the data as though they are organized at single level. There are three models which are related within variables and each model is nested among the model. As model 1, the analysis focused at the effect of gender on attitudes towards science. For model 2, the analysis was taking into account of other factors. Thus, analysis at this level concentrates on the effect of gender in science and considers other factors such as the level of computer use, parental concerns and students' perception about their school. Then, the model 3 is different from model 2 and model 1 where analysis is focusing on the effect of gender in science and considers other factors such as the level of computer use, parental concerns, and students' perception about their school and also considered different types of school. But this time, the principle of multilevel modeling is taken into account. In model 3, treated schools where the students belong to as another level of data. Thus, data for model 3 in form of hierarchical data which are on two levels namely students at first level and schools at second level.

4-1. Output Model 1

Table-1. The Result of Model Dimension[a]

		Number of Levels	Number of Parameters
Fixed Effects	Intercept	1	1
	Gender	1	1
Residual			1
Total		2	3

a. Dependent Variable: Attitude towards Science.

Table-2. The Result of Information Criteria[a]

-2 Log Likelihood	36748.322
Akaike's Information Criterion (AIC)	36754.322
Hurvich and Tsai's Criterion (AICC)	36754.326
Bozdogan's Criterion (CAIC)	36777.109
Schwarz's Bayesian Criterion (BIC)	36774.109

The information criteria are displayed in smaller-is-better forms.
a. Dependent Variable: Attitude towards Science.

Table-3. The Result of Fixed Effects Test[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	5409	74425.882	0.000
Gender	1	5409	.341	0.559

a. Dependent Variable: Attitude towards Science.

As can be observed from model 1, the gender did not significantly predict attitudes towards science, $F(1,5409) = 0.341$, $P=0.559$ (Table 3). This variable indicated no effect of students' attitude on gender.

4-2. Output Model 2

Table-4. The Result of Model Dimension[b]

		Number of Levels	Number of Parameters
Fixed Effects	Intercept	1	1
	Gender	1	1
	Computer	1	1
	Parent	1	1

Continue

School	1	1
Residual		1
Total	5	6

b. Dependent Variable: Attitude Towards Science.

Table-5. The Result of Information Criteria[b]

-2 Log Likelihood	33293.737
Akaike's Information Criterion (AIC)	33305.737
Hurvich and Tsai's Criterion (AICC)	33305.754
Bozdogan's Criterion (CAIC)	33350.774
Schwarz's Bayesian Criterion (BIC)	33344.774

The information criteria are displayed in smaller-is-better forms.

b. Dependent Variable: Attitude towards Science.

Table-6. The Result of Fixed Effects Test[b]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	4945	15405.104	0.000
Gender	1	4945	2.401	0.121
Computer	1	4945	0.012	0.912
Parent	1	4945	37.116	0.000
School	1	4945	224.655	0.000

b. Dependent Variable: Attitude towards Science.

Table-7. The Result of Correlation Matrix for Estimates of Fixed Effects[b]

Parameter	Intercept	Gender	Computer	Parent	School
Intercept	1	-0.479	-0.734	-0.238	-0.391
Gender	-0.479	1	0.153	-0.065	-0.011
Computer	-0.734	0.153	1	-0.094	0.072
Parent	-0.238	-0.065	-0.094	1	-0.258
School	-0.391	-0.011	0.072	-0.258	1

b. Dependent Variable: Attitude towards Science.

Table-8. The Result for Estimates of Covariance Parameters[b]

					95% Confidence Interval	
Parameter	Estimate	Std. Error	Wald Z	Sig.	Lower Bound	Upper Bound
Residual	49.152671	0.988505	49.724	0	47.25292	51.1288

b. Dependent Variable: Attitude towards Science.

Further analysis of the data in model 2 was carried out to examine the association between attitudes of students towards sciences and the background variables which include gender, computer usage, parental concern and perception toward school. The result shows the gender still did not significantly predict attitudes towards science, $F(1,4945) = 2.401$, $P=0.121$ and also students' level using computer did not significantly predict attitudes towards science, $F(1,4945) = 0.012$, $P=0.912$. Nevertheless, the parental concern, $F(1,4945) = 37.116$, $P=0.000$ and students' perception about their school, $F(1,4945) = 224.655$, $P=0.000$ significantly predict attitudes towards science. These two variables indicated no effect of students' attitude on gender. Conversely, there is a significant effect of parental concern towards homework and students' perception about their school on students' attitude toward science.

4-3. Output Model 3

Table-9. Model Dimension[c]

		Number of Levels	Covariance Structure	Number of Parameters	Subject Variables
Fixed Effects	Intercept	1		1	
	Gender	1		1	
	Computer	1		1	
	Parent	1		1	
	School	1		1	
Random Effects	Intercept[a]	1	Variance Components	1	IDSCHOOL
Residual				1	
Total		6		7	

a. As of version 11.5, the syntax rules for the RANDOM subcommand have changed. Your command syntax may yield results that differ from those produced by prior versions. If you are using version 11 syntax, please consult the current syntax reference guide for more information.

c. Dependent Variable: Attitude Towards Science.

Table-10. The Result of Information Criteria[c]

-2 Log Likelihood	33040.853
Akaike's Information Criterion (AIC)	33054.853
Hurvich and Tsai's Criterion (AICC)	33054.876
Bozdogan's Criterion (CAIC)	33107.396
Schwarz's Bayesian Criterion (BIC)	33100.396

The information criteria are displayed in smaller-is-better forms.

c. Dependent Variable: Attitude towards Science.

Table-11. The Result of Fixed Effects Test[c]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	4076.506	13407.67	0.000
Gender	1	4944.856	5.383	0.020
Computer	1	4823.941	0.020	0.888
Parent	1	4929.451	30.723	0.000
School	1	4912.304	168.077	0.000

c. Dependent Variable: Attitude towards Science.

Table-12. The Result of Correlation Matrix for Estimates of Fixed Effects[c]

Parameter	Intercept	Gender	Computer	Parent	School
Intercept	1	-0.472	-0.724	-0.255	-0.378
Gender	-0.472	1	0.166	-0.049	-0.013
Computer	-0.724	0.166	1	-0.076	0.058
Parent	-0.255	-0.049	-0.076	1	-0.228
School	-0.378	-0.013	0.058	-0.228	1

c. Dependent Variable: Attitude towards Science.

Table-13. The Result for Estimates of Covariance Parameters[c]

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Residual	44.45143	0.910863	48.801	0	42.701547	46.27302
Intercept [subject = IDSCHOOL] Variance	4.788912	0.689308	6.947	0	3.611738	6.349762

c. Dependent Variable: Attitude towards Science.

Table-14. The Result of Correlation Matrix for Estimates of Covariance Parameters[c]

Parameter	Residual	Intercept [subject = IDSCHOOL] Variance
Residual	1	-0.053
Intercept [subject = IDSCHOOL] Variance	-0.053	1

c. Dependent Variable: Attitude towards Science.

Table-15. The Group of Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Attitude Towards Science	GIRL	2750	84.4884	7.15339	.13641
	BOY	2659	84.6032	7.30792	.14172

According to model 3, the critical values for the chi-square statistic with 1 degree of freedom, are 3.84 ($p<0.05$) and 6.63 ($p<0.01$); therefore, this change (chi square change=252.88) is highly significant based on the effects of variables in the table of fixed effects (Table11). By modeling this variability in intercepts, our model is significantly improved. It can be concluded that the intercepts for the relationship between parental concern towards homework and attitude towards science (when controlling for School ID) vary significantly across different gender. By allowing the intercepts to vary over gender, the attitude towards science has decreased dramatically.

The attitudes towards science of students by gender, student's level of computer usage, parental concern about the children's study and perception students towards school are shown in Table 10. There are three variables shows the significant difference in attitude towards science with *p-value* less than 0.05. As can be observed, boys have more positive attitudes towards science compared to girls (Table 15). Number of male respondents was 2,750 students (50.8%) while the number of female respondents was 2659 students (49.2%). This means that male respondents are more than the female respondents. The difference between female and male respondents was 91 at 1.7 percent. In addition, the mean for male students (84.60) was higher than the mean for female (84.49).

Other two variables also indicated the significant difference in attitude towards science which is parental concern about the children's study and perception students towards school. It is interesting to note that the more parental concern of student homework, the more positive attitude of students towards science. So, the support system from parents at home is important to ensure the students have always completed their school work. Base of the analysis, the more positive students' perception on school the students interest in science also increase. Actually students' interest toward science does not just depend on the teaching and learning in classroom but also in the school environment must be viewed positively by students.

5. DISCUSSION

This study clearly shows that the attitudes and achievement orientation of students towards learning of science subject are found to be desire. Although the students' attitudes and achievement orientations towards learning of science vary according to the background variables, it appears that the gender, parental concern about the children's study and perception students towards school is a major intervening factor that has emerged strongly out of this study.

The results of this study show significant gender differences in attitudes towards science for Malaysian eight grade students in TIMSS 2011. The TIMSS 2011 data showed that males reported having more interests in the science than their female peers. These findings support those found by Kim *et al.* (2000) and the finding are consistent with Becker (1989) and Weinburgh (1995). They claimed that boys showed more favorable attitudes towards science compare to girls. Students' attitudes towards science also vary with the specific science according to the gender (Osborne and Collins, 2000). According to the Jones *et al.* (2000) boys are more interested in the physical science areas and girls are more interested in the biological science areas. Their study also shows males are interested in atomic bombs, atoms, cars, computers, x-rays, and technology. While female's interests more in the biology, including animal communication, rainbows, healthy eating, and AIDS (Jones *et al.*, 2000). Therefore, the role of the teacher is highly emphasized in influencing male students reading and selecting materials reading (Mac Donald *et al.*, 1999) to attract male student's interest towards science. Kim *et al.* (2000) suggested that the female student's attitude towards science can be improved when the learning environment was improved.

From the results of the model clearly show that the effects of the parental concern variable were consistently significant influence on attitudes toward science, the finding is similar result with previous studies (Keeves, 1975; George and Kaplan, 1996; George, 2000). It shows that parent play an important role in student's education and very concern about their children studying. Almost every day parents allocate time to monitor their children's homework, what and how they learn in school (Ismail and Awang, 2008). Chen (2001) discovers that parents spend their time sitting together with their children and checked their children's homework. Besides, the parents knew what their child was doing in school by way of homework that they bring home (Allen and Fraser, 2007). The students who spend their time on doing the homework would have higher achievement than students who do little or no homework (Ismail and Awang, 2012). From the time spending on homework will reflect the interest students towards the subject. Meanwhile, other researchers found that mother's and father's attitudes towards science were positively related to their children's (Simpson and Oliver, 1990). In addition, mothers and fathers have differential influence on the children. Mothers encourage their children to do well in science is more than fathers (Breakwell and Beardsell, 1992).

This study also found that there was a positive association between student's perception towards school and science achievement. Students with positive perceptions towards school makes students feel very comfortable to learn and feel safe when they are in school, the finding is in agreement with that of (Ismail and Awang, 2012). In addition, students feel free to interact and communicate with teachers, friends or anyone else in the school. Teachers and students will be more motivated and at the same time teaching and learning activities will smoothly in harmony school environment (Kim *et al.*, 2000). As such, the interests of students in science are encouraged. Besides, students who are satisfied with the learning environment in school will be able to improve students attitudes' toward science (Fraser, 1998; Kim *et al.*, 2000; Allen and Fraser, 2007).

6. IMPLICATION

The findings of this study provide direct implications on the implementation of science education in Malaysia, particularly at the secondary level. There are several things that can be addressed in the context of student interest in science. Malaysian Ministry of Education (MOE) policy-makers should focus on the fair distribution of educational resources. Clearly, teachers must have the credibility and responsibility to educate science as equally same both for girls and boys without any bias in gender. Also efforts to promote science not only as a burden rest solely on science teacher. Parental concern seen plays a role to encourage more parents to take care of schoolwork that were brought back by students, especially in science subjects. Further, the school environment should be cultivated toward fostering students' interest in science. Thus, teachers and school principals should monitor the utilization level of resources such as teaching aid, science laboratories, computer usage and library search. It is very important they facilitate the effective use of these resources and make them available for teachers and students.

The implications of these findings could serve as a guideline for Malaysian Ministry of Education (MOE) so that they provide teachers with appropriate training before they enter the profession as well as in-service training programs to help them understand the importance of teaching and how to teach effectively. Furthermore, the findings also important for educational practitioners and curriculum developers so that they can ensure that the utilized educational policies and also parental concern activities would help students to promote positive attitudes toward science.

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