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FACTORS RELATED TO SCIENCE ACHIEVEMENT IN TIMSS MALAYSIA: A CONFIRMATORY FACTORS ANALYSIS

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Abstract: This study aims to examine the factors related to students' science achievement in TIMSS 2011. This study involved a total of 5733 respondents from 180 secondary schools in Malaysia based on TIMSS 2011 data. Random sampling using a two-stage stratified cluster sampling technique was done in selecting the sample. This study also proposes a model containing two exogenous constructs which are parental involvement and school discipline as well as two endogenous constructs which are attitudes towards science and science achievement. This study used the structural equation modelling (SEM) technique to test the hypothesized model and to determine the strength of the relationship between one variable with another variable. The findings showed that parental involvement has a positive relationship on students' attitudes toward science and students' science achievement while the student attitudes towards science have a negative relationship towards students' science achievement.

Keywords: Parental involvement, Attitudes towards science, Science achievement, TIMSS.

INTRODUCTION

TIMSS is a large-scale assessment and research project designed to measure the level of students grade 4 and grade 8 in mathematics and science education at the international level. TIMSS is designed to align the mathematics and science curriculum and education system widely in the countries that participated (Mullis, Martin, Minnich, et. al., 2012). In addition, the TIMSS achievement of a country can demonstrate the extent to which students have knowledge in mathematics, science and skills in real-life contexts being taught in school (Martin, Mullis, Foy, & Stanco, 2012; Mullis, Martin, Foy, & Arora, 2012). This assessment is the benchmark for the Malaysian education system in order to provide an opportunity for the country to investigate the weaknesses and strengths of students by referring to the various fields of knowledge and cognitive skills (Martin & Mullis, 2006).

Malaysia has participated in TIMSS four times in 1999, 2003, 2007 and 2011, but it only involved eighth-grade students. Based on the report of TIMSS 1999 to TIMSS 2011, science scores showed students in Malaysia were found to have declined below average in the TIMSS scores when compared with students in other Asian countries (Singapore, Hong Kong, Japan, Korea and Taiwan). The average score of students in the TIMSS science achievement in 1999 (Martin

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et. al., 2000), 2003 (Martin, Mullis, Gonzalez, & Chrostowski, 2004), 2007 (Martin, Mullis, & Foy, 2008) and 2011 (Martin et. al., 2012) were 492, 510, 471 and 426 respectively. The scores of students in Malaysia was ranked 22nd out of 38 countries in TIMSS 1999, ranked 20th out of 50 countries in TIMSS 2003, ranked 21st out of 60 countries in TIMSS 2007 and ranked 32nd out of 45 countries in TIMSS 2011. Overall, the science scores of Malaysian students in TIMSS 2007 (Martin et. al., 2008) and TIMSS 2011 (Martin et. al., 2012) were below the score of 500 (minimum score level suggested by TIMSS) which are categorized as low in the International Benchmark.

TIMSS achievement results provide an excellent opportunity to visualize the results of student learning in mathematics and science. Thus, this study was conducted to examine the factors related to student's science achievement in TIMSS.

PREDICTORS AFFECTING SCIENCE ACHIEVEMENTS

Numerous research claimed that parental involvement in learning activities at home (reading to children, encouragement of reading, and spending time for homework) supports what the schools are doing and it is significant in relation to the academic achievement of students (Jeynes, 2016; Kocayörük, 2016; Goodwin, 2015; Alvarez-Valdivia, 2012; Fan & Williams, 2010; Harris & Goodall, 2008; Jeynes, 2007). Parents who participated and got involved with the activities organized by the school show better performance compared with parents who do not engage in activities organized by the school (Jeynes, 2012). Colgate (2016), Jeynes (2007) and Harris & Goodall, (2008) also found that parents who play the role of teachers at home and have a positive stance against children would prefer to engage in cognitive activities of children. The lower parental involvement shown by parents from the beginning will leave a lower academic aspirations for their children (Pahic & Miljevic-Ridicki, 2011).

The parental involvement at home can be seen from the enthusiasm of parents in caring for their children's education. Parents who are aware of the responsibility of providing appropriate facilities for the education of children are found to affect children's enthusiasm for learning (Desimone, 1999; Fan & Chen, 2001; McNeal, 1999). Children are given the opportunity to develop their potential through the encouragement and support from parents at home. The study by Epstein (2008) found that children whose parents spend time with to do school homework will be more successful and have a desire to do their best. This is because the parents become mentors to children in learning at home.

School discipline refers to the perception of safety at schools (Crosnoe, Johnson, & Elder, 2004; Planty, DeVoe, Owings, & Chandler, 2005), fairness and effectiveness of discipline at schools (Ma, 2003), enforcement of school rules (Brand, Felner, Shim, Seitsinger, & Dumas, 2003; Ma, 2003) and also the frequency of incidents of indiscipline among students at schools (Brand et. al., 2003). School discipline is found positive when associated with academic achievement (Gregory et. al., 2010; Brand et. al., 2003) and dropouts (Archambault et. al., 2009; Skiba & Peterson, 2000). Prior research shows that students' perceptions of school rules is positive when associated with the safety of students (Ingels, Burns, Chen, Cataldi, & Charleston, 2005; Welsh, 2000) and negative when associated with disruption at school, such as student misconduct at school (Gottfredson, Gottfredson, Payne, & Gottfredson, 2005; Welsh, 2000).

Moreover, many empirical studies have found that student attitudes towards science has become increasingly negative since the mid-20th century. Two studies conducted by Osborne et. al., (2003) in the United Kingdom showed a large drop in enrolment in science courses. Both studies show that students graduated in fields from science to other disciplines. Students felt that science subjects are difficult to understand and boring (Barmby, Kind, & Jones, 2008). This shows that attitudes towards learning have a significant impact on the results of their learning process. In any learning process, an attitude is not only a causal or input variable, it also needs to be considered as an output or may vary outcomes. The attitude is important because it can affect the student's achievement (Alias et. al., 2014). Therefore, a positive attitude towards a subject maybe last longer than the knowledge gained when passing an examination.

Therefore, this study was carried out to test a model that shows the related factors that affect student science achievement in high school by using TIMSS 2011 data. In addition, the study also uses the structural equation modeling (SEM) in order to provide information on the strength of the relationship between parental involvement, school disciplinary and attitude towards science on science achievement of students.

METHODS

The present study was based on the structural equation modeling (SEM) to analyze the student questionnaire and student achievement scores in science as revealed by TIMSS 2011 data in Malaysia. The reason for using SEM is that it enables researchers to match theories with the data, to decide on the extent to which they fit each other, to test the hypothesized model and to determine the strength of the relationship between one variable with other variables simultaneously (Byrne, 2001).

Source of Data

The data used in this study is generated from TIMSS's most recent database. The information was collected from the Malaysian eight graders in 2011. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA). It has been more than 50 years for IEA in conducting comparative studies of educational achievement in a number of curriculum areas including mathematics and science. TIMSS 2011 represents the fifth cycle of the

Trends in International Mathematics and Science Study (TIMSS). TIMSS has been conducted every four years since 1995.

Population and Sample

The population of the study comprised eight graders in Malaysia. The sample consisted of 5733 students (2918 boys and 2815 girls) from 180 randomly chosen schools in Malaysia that participated in the TIMSS 2011. The sample was chosen through a stratified two-stage sampling (Foy & Joncas, 2000). The first stage included the selection of the schools using a random sampling from all the secondary schools in Malaysia. For each school, a single classroom of eighth grade pupils was selected at random in the second stage. Pupils from these selected classes were asked to complete pupils' questionnaires. Details of the sampling procedure, background information of the students, and schools as well as science questions and achievement can be found in TIMSS reports (Olson, Martin, & Mullis, 2008).

Measured Variables

Items were selected for the structural equation modelling to fit a model from TIMSS questionnaires based on the literature. Items for the home environment, school environment and student background variables were selected from the student questionnaire. Also the variable of student achievement in science was taken from the student scores in the science test. Each item used a different categorical Likert-type scale based upon item format. Four latent variables were of particular interest in this study: (i) parental involvement, (ii) school disciplinary climate, (iii) attitudes towards science, and (iv) science achievement.

Analysis

Data analysis was based on the SEM approach to test hypothesized models (Ismail *et. al.*, 2015). For maximum likelihood estimate, a set of goodness-of-it index were used to evaluate model fit: chi-square ($\chi 2$), root mean square error of approximation (RMSEA), comparative fit index (CFI) and Tucker–Lewis index (TLI). Furthermore, Akaike information criterion (AIC) and Bayesian information criterion (BIC) were used to help compare models (Loehlin, 2004). Small values on AIC and BIC suggest better models in terms of model fit and parsimony. In addition, AIC difference (ΔAIC), a measure of a less-plausible fitted model relative to the best model, was calculated to examine whether the models were essentially equivalent with each other. ΔAIC values lying between 0 and 2 suggest substantial evidence to support the equivalency of the models, values between 3 and 7 indicate that the less- plausible fitted model has considerably less support, and values higher than 10 indicate that this model is very unlikely (Burnham & Anderson, 2002). All analyses were performed using AMOS18.

RESULTS

The results of the analyses are reported for confirmatory factor analysis (CFA). In studies forming a model with latent variables, it is necessary to measure each measurement model separately before the analysis (Byrne, 2001). The measurement models must be similar to a confirmatory factor analysis and any unconfirmed measurement model should be excluded from the model. Through SEM, confirmatory factor analysis (CFA) was performed on the four measures (i.e. parental involvement, school disciplinary, attitudes towards science and science achievement) to examine the data structure as a whole (Figure 1).

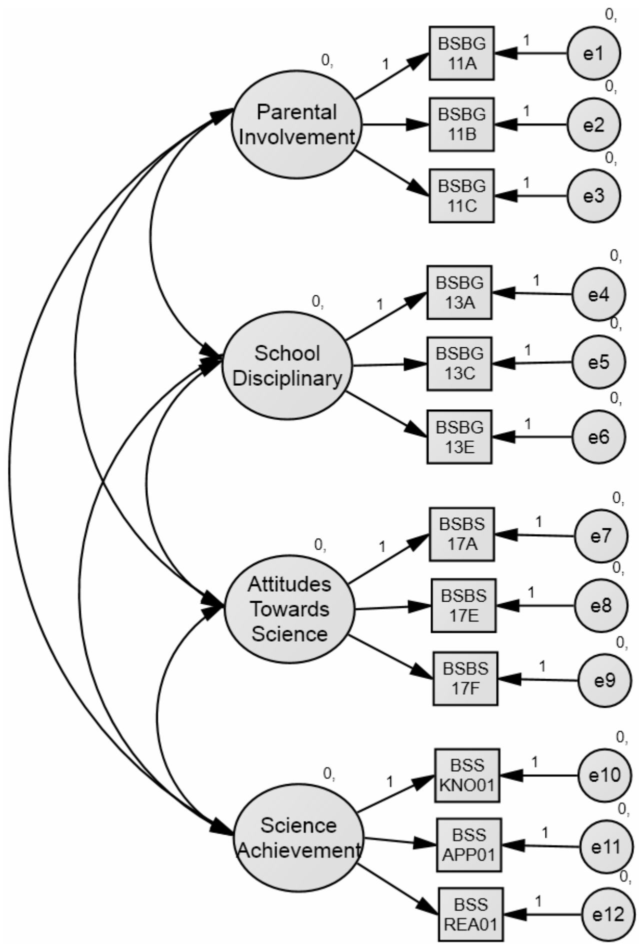

Figure 1: Measurement Model

The following goodness-of-fit indices suggested that the data fit adequately the four components for the measurement models: $\chi 2$ (N = 5535, $df = 48$) = 755.897, $p < 0.05$. Table 1 presents the standardized factor loadings. All factor loadings were higher than 0.30, which met the minimal criterion to consider an item as valid. Thus, the verification measurement model will be the basis for testing the structural model (Bentler & Bonett, 1980).

TABLE 1: STANDARDIZED FACTOR LOADINGS FOR MEASUREMENT MODEL

			Estimate
BSBG11A	<——	Parental Involvement	.713
BSBG11B	<——	Parental Involvement	.807
BSBG11C	<——	Parental Involvement	.531
BSBG13A	<——	School Disciplinary	.583
BSBG13C	<——	School Disciplinary	.572
BSBG13E	<——	School Disciplinary	.492
BSBS17A	<——	Attitude Towards Science	.862
BSBS17E	<——	Attitude Towards Science	.705
BSBS17F	<——	Attitude Towards Science	.909
BSSKNO01	<——	Science Achievement	.948
BSSAPP01	<——	Science Achievement	.980
BSSREA01	<——	Science Achievement	.973

Measurement Model Analysis of Group Invariant and Group Variant Findings

For this multi-group analysis, the measurement models for the individual latent constructs, and for the constructs taken in pairs across variable, were estimated using the data from the sample of males and females. In this analysis, there are two data sets each containing 12 measurement variables. Two covariance matrices generated from the two data sets contain 180 sample moments. For the group invariant model there are 76 parameters to be estimated. Therefore it has 104 (180 – 76) degrees of freedom and yield significant chi-square value, (N = 5535, $df = 104$) = 820.88, $p < 0.05$ (Table 2). For the measurement model variant, there are 84 parameters to be estimated. This model, therefore, has 96 (180-84) degrees of freedom, and yielded a significant chi-square value, $\chi 2$(N = 5355, $df = 96$) = 810.23, $p < 0.05$ (Table 2).

Table 2 shows the baseline comparison fit indices of NFI, RFI, IFI, TLI, and CFI for both models are above 0.90 (range: 0.974 – 0.982). The RMSEA values for both group-invariant and group-variant path models are 0.035 and 0.037, respectively.

RMSEA values ranging below 0.08 are acceptable (Hair et. al., 2013). These values suggest that the fit of these two models is adequate.

TABLE 2: CHI-SQUARE GOODNESS OF FIT, BASELINE COMPARISONS FIT INDICES AND RMSEA FOR GROUP INVARIANT AND GROUP VARIANT

CMIN

Model	*NPAR*	*CMIN*	*DF*	*P*	*CMIN/DF*
Group invariant	76	820.886	104	.000	7.893
Group variant	84	810.232	96	.000	8.440
Saturated model	180	.000	0		
Independence model	48	39683.661	132	.000	300.634

BASELINE COMPARISONS

Model	*NFI Delta 1*	*RFI Rho 1*	*IFI Delta 2*	*TLI Rho 2*	*CFI*
Group invariant	.979	.974	.982	.977	.982
Group variant	.980	.972	.982	.975	.982
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

RMSEA

Model	*RMSEA*	*LO 90*	*HI 90*	*PCLOSE*
Group invariant	.035	.033	.038	1.000
Group variant	.037	.034	.039	1.000
Independence model	.233	.231	.235	.000

TABLE 3: AKAIKE INFORMATION CRITERION AND NESTED MODEL COMPARISONS STATISTICS

Nested Model Comparisons Assuming Model Group Variant to be Correct							
Model	*DF*	*CMIN*	*P*	*NFI Delta-1*	*IFI Delta-2*	*RFI Rho 1*	*TLI Rho 2*
Group invariant	8	10.654	.222	.000	.000	–.002	–.002

TABLE 4: AKAIKE INFORMATION CRITERION OUTPUT

Model	*AIC*	*BCC*
Group invariant	972.886	973.604
Group variant	978.232	979.026
Saturated model	360	361.701
Independence model	39779.7	39780.1

From the CMIN statistics, it can be seen that the chi square difference value for the two models is 10.654(820.886-810.232) (Table 2). With 8 degrees of freedom (104– 96), this value is significant at the 0.05 level ($p > 0.05$). Thus, the two models differ significantly in their goodness-of-fit. Based on the goodness of fit criteria, both invariant and variant models fit the data well. Therefore the fit of the two models can also be compared using the AIC measure (Akaike, 1981, 1987). In evaluating the hypothesized model, this measure takes into account both model parsimony and model fit. Simple models that fit well receive low scores, whereas poorly fitting models get high scores. The AIC measure for the group-invariant model (972.886) which is slightly lower than that for the group-variant model (978.232), indicating that the group invariant model is both more parsimonious and better fitting than the group variant model. Therefore, on the basis of the model comparisons findings, and assuming that the group-invariant model is correct, the group-invariant model's estimates are preferable over the group-variant model's estimates.

For this multi group analysis, there are two data sets (for males and females), each containing 12 measurement variables. The two covariance matrices generated from the two data sets contain 180 sample moments. For the group-invariant model, there are 71 parameters to be estimated. This model therefore has 109(180 – 71) degrees of freedom, and yielded a significant chi-square value, $\chi 2$ (N = 5535, $df = 109$) = 827.02, $p < 0.05$, $p < 0.05$. For the group-variant model, there are 76 parameters to be estimated. This model, therefore, has 104(180-76) degrees of freedom, and also yielded a significant chi-square value, $\chi 2$ (N = 5355, $df = 104$) = 820.88, $p < 0.05$.

Table 9 presents the chi-square goodness-of-fit statistics; baseline comparisons fit indices and model comparison statistics for the group-invariant and group-variant path models. Although the chi-square values for both path models are statistically significant (i.e., both models yielded poor fit by the chi-square goodness-of-fit test), the baseline comparison fit indices of NFI, RFI, IFI, TLI, and CFI for both models are above 0.90 (range: 0.974 to 0.982). These values suggest that the fit of these two models is adequate.

TABLE 9: CHI-SQUARE GOODNESS OF FIT, BASELINE COMPARISONS FIT INDICES AND RMSEA FOR STRUCTURAL VARIANT MODEL AND INVARIANT MODEL

CMIN

Model	*NPAR*	*CMIN*	*DF*	*P*	*CMIN/DF*
Group invariant	71	827.023	109	.000	7.587
Group variant	76	820.886	104	.000	7.893
Saturated model	180	.000	0		
Independence model	48	39683.661	132	.000	300.634

BASELINE COMPARISONS

Model	*NFI Delta 1*	*RFI Rho 1*	*IFI Delta 2*	*TLI Rho 2*	*CFI*
Group invariant	.979	.975	.982	.978	.982
Group variant	.980	.974	.982	.977	.982
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

RMSEA

Model	*RMSEA*	*LO 90*	*HI 90*	*PCLOSE*
Group invariant	.035	.032	.037	1.000
Group variant	.035	.033	.038	1.000
Independence model	.233	.231	.235	.000

These indices compare the fit of the hypothesized model to the null or independence model. With the incremental fit indices ranging from 0.974 to 0.982, the possible improvement in fit for the hypothesized model (range: 0.055 to 0.088) appears to be small as to be of little practical significance (Bentler & Bonett, 1980). The RMSEA fit index, which takes into account the error of approximation in the population, yielded values for the group-invariant and group-variant path models of 0.035 and 0.035, respectively. Values ranging below 0.08 are acceptable (Browne & Cudeck, 1992; Schermelleh-engel, Moosbrugger, & Müller, 2003). Thus, the RMSEA values for the group-invariant and group-variant path models suggest that the fit of these two models is adequate.

The fit of the two competing models can be directly compared. From the Nested Model Comparisons statistics (Table 10), it can be seen that the chi-square difference value for the two models is 6.137 (827.023 – 820.886). With 5 degrees of freedom (109 – 104), this statistic is not significant due to *p*-value was 0.293 ($p > 0.05$). Thus, both the structural model did not differ significantly on the goodness of fit statistic. The structural regression weights model and standardized regression weights model for the invariant groups of male and female showed (i) positive significant relationship between parental involvement and attitudes towards science by the critical ratio test ($> \pm 1.96$, $p < 0.05$); (ii) positive significant relationship between parental involvement and science achievement by the critical ratio test ($> \pm 1.96$, $p < 0.05$) and; (iii) negative significant relationship between attitudes towards science and science achievement by the critical ratio test ($> \pm 1.96$, $p < 0.05$). Another two non-significant coefficients with the paths linking from school disciplinary to attitudes towards science by the critical ratio test ($< \pm 1.96$, $p > 0.05$) and from school disciplinary to science achievement by the critical ratio test ($< \pm 1.96$, $p > 0.05$) was discovered.

DISCUSSION AND CONCLUSION

The tested model shows that there is a significant positive relationship between parental involvement and attitude towards science. In this study, the indicators of parental involvement are: (i) student learning is concerned, (ii) discuss schoolwork student and (iii) allocating time for school work student. These indicators were found to be contributing to the positive attitude of students towards science. The study was in line with the findings by Papanastasiou dan Papanastasiou (2006) which discovered that parental involvement has a positive correlation with attitudes toward mathematics. This means that the higher the parents' involvement in supporting student learning at home, the more positive student attitudes toward learning (Battle-Bailey, 2004; Papanastasiou & Papanastasiou, 2006; Floyd & Vernon-Dotson, 2009; Rogers et. al., 2014; Mora & Escardíbul, 2016).

Parents who practice a concerned attitude towards the students' academic progress at home can create a culture of science in the family environment (Fan & Chen, 2001; Zhang, Hsu, & Kwok, 2011). The attitude of parents who always emphasized education of children is the driving force for parents involved in any form of education, especially at home (Knollmann & Wild, 2007; Floyd & Vernon-Dotson, 2009; Rogers et. al., 2014; Mora & Escardíbul, 2016). Parenting practice which practiced the culture of knowledge will have an impact not only on children to succeed in their studies and even their own parents feel encouraged to be concerned and keep abreast of their children's education development (Knollmann & Wild, 2007; Kordi, 2010).

The tested model also shows that there is a significant positive relationship between parental involvement and science achievement. This finding is consistent with findings in countries such as the USA (Tare, French, Frazier, Diamond, & Evans, 2011), Canada (Ratelle & Larose, 2005), Hong Kong (Ho, 2010) and Nigeria (Olatoye & Ogunkola, 2008; Oluwatelure & Oloruntegbe, 2010) that show parental involvement has a significant correlation with student achievement in science. The study found that interaction and two-way communication, as well as being family-friendly can help parents understand and acknowledge the current development of children. Parents who practiced interaction and two-way communication as well as the friendship between parents and children also can help the parents to be more actively involved in the education of children (Barge & Loges, 2003; Knollmann & Wild, 2007). In other words, closeness between parents and children in the family will stimulate the parents to take greater care and pay attention to children including matters related to their education (Defrain & Asay, 2007)

Further, these findings are also supported by Barge and Loges (2003) who found that parents should monitor their child's academic progress through report cards, progress reports, and keeping in touch with the teacher. This allows parents to keep abreast of child's academic progress by providing space for children to deliver information about their education freely. Children need support from parents not only as a mentor but as a friend in case of problems (Cohen & Canan, 2006). With this, the children feel free and comfortable to express wants and needs, including when they encounter difficulties either in education or things of a personal nature. At the same time parents are responsible for being involved directly or indirectly in children learning activities (Papanastasiou & Papanastasiou, 2004; Floyd & Vernon-Dotson, 2009; Rogers et. al., 2014; Mora & Escardíbul, 2016).

The tested model also showed a significant negative correlation between attitudes towards science and science achievement of students. In this study, the students claimed they enjoyed learning science, learn many interesting things in science and are interested in science, which shows that attitudes towards science are important in determining student achievement in science. However, the results showed that students' attitude toward science was high but student achievement is low. Most students are only interested in science and are unable to obtain a high score in the TIMSS 2011 science test. This finding is also consistent with the findings of the TIMSS 1999 study conducted by researchers like Uzun, Gelbal, & Ogretmen (2010) in Turkey. Although these findings seem to contradict the study and the usual assumption, it is still possible to see the issue from a different point of view. The difference between this study and previous research findings may be important for the assessment of science education in Malaysia.

Most students have a positive attitude and agree that science is important in their lives (Ismail et. al., 2014). However, the positive attitude of Malaysian students in science is not in line with students' achievement in science. The findings show that the achievement of science does not reflect the real attitude of students towards science. This is likely due to the system of examination-oriented education in Malaysia where science achievement is measured through examination (Kirkpatrick & Zang, 2011). Students placed more importance on science achievement in examinations. This causes students to focus more on memorizing rather than understanding the basic concepts of science (Uzun et. al., 2010).

Previous studies have found that enjoyment in science can be seen when students feel excited and have fun while doing science learning activities (Osborne et. al., 2003). In addition, the enjoyment of science can be described through fun learning science in the classroom, engaging in the lab, talking about science, watching science programs and reading science oriented materials (Ismail et. al., 2014). But in this study, the students feel that they enjoy and feel good with science, however they still cannot master science as a whole because they do not understand the basic concepts of science and are not proficient in science activities (Osborne et. al., 2003; Uzun et. al., 2010). This was apparent from the findings of the 2011 TIMSS results which showed Malaysian student scores in science below the minimum scores as determined by the International Association for the Evaluation of Educational Achievement (IEA) (Mullis, Martin, Foy, et. al., 2012).

CONCLUSION

This study has found that parental involvement, school disciplinary climate and attitudes towards science are the possible factors for student's science achievement. Nevertheless, the tested model showed that there is no relationship between school discipline with attitudes towards science and school discipline with science achievement of students. In summary, school discipline does not contribute to the attitudes towards science and science achievement of students in TIMSS 2011. As a conclusion, to enhance the science achievement, manipulation of parental involvement and attitudes towards science must be managed accordingly. In short, it is encouraged that the parents to play their role effectively and good student's attitude contributes to better achievement in science.

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