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Research paper

Contributing Factors to Science Achievement in TIMSS Malaysia: Direct Model and Indirect Model

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Abstract

The purpose of this study is to examine the extent to which home context, classroom context and school context influence students' science achievement in Trends in International Mathematics and Science Study (TIMSS) 2011. This study involved a total of 5733 respondents from 180 secondary schools in Malaysia based on TIMSS 2011 data. Random sampling using 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 structural equation modeling (SEM) technique to test the direct model, indirect model and to determine the strength of the relationship between one variable with another variable. The findings showed that parental involvement has a direct effect on students' attitudes toward science and students' science achievement while the student attitudes towards science have a negative relationship towards students' science achievement.

Keywords: *Attitudes; Disciplinary; Parental Involvement; Science Achievement and TIMSS*

1. Introduction

Education plays an important role in improving the quality of human resources in order to have a high competitive and able to face global challenges. Because of that, the assessment was conducted on the various aspects related to the quality of education in the national interest. These include assessments conducted to see student achievement, especially at the international level [1]. Therefore, Malaysia has consistently joined the international benchmark that evaluates the quality and student achievement in science and mathematics that is Trends in International Mathematics and Science Study (TIMSS) [2-4].

TIMSS is a series of international assessment and research projects designed to measure the level of student's 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 [2] Furthermore, the TIMSS achievement of participated country can demonstrate the extent to which students have knowledge in mathematics, science and skills in real-life contexts being taught in school [2, 3]. The TIMSS results is a 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 [5]

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' behaviour, 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. 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. Therefore, this study proposes to conduct secondary analyses of the TIMSS datasets to explore the very modest performance in science and to explain students' science achievement in terms of contextual and background variables available in these datasets and associated information sources.

2. Predictors Towards Science Achievements

Previous researcher 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 [6, 7]. 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 [6, 8] . Colgate, et al. [9], Harris and Goodall [10],

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Jeynes [11] and 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 [12].

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 [13]. Children are given the opportunity to develop their potential through the encouragement and support from parents at home. The study by Núñez [14] found that children whose parents spend time with to do 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 [15], fairness and effectiveness of discipline at schools [16] enforcement of school rules [17] and also the frequency of incidents of indiscipline among students at schools [18] . School discipline is found positive when associated with academic achievement [19] and dropouts [20]. Prior research shows that students' perceptions of school rules is positive when associated with the safety of students [21] and negative when associated with disruption at school, such as student misconduct at school [22]

Moreover, many empirical studies have found that students' attitudes towards science have become increasingly negative since the mid-20th century. Two studies conducted by Murphy [23] and Kennedy, et al. [24] in the Australia 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 [25]. 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 [26]. Therefore, a positive attitude towards a subject maybe last longer than the knowledge gained when passing an examination.

3. Methods

The present study was based on structural equation modelling (SEM) to analyze the student questionnaire and student achievement scores in science as revealed by TIMSS 2011 data on 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 analysis [27].Considering that variables in achievement cannot be measured directly, they can be accounted for through the measurement of certain observable variables that define or are thought to define them [28].Since the use of latent variables enables errors in such variables to be identified, estimated values of variables in SEM studies are much more reliable [27]. SEM is a comprehensive statistical approach used to test the models characterized by causal and correlational relationships between observable and latent variables, and it allows one to study the set of relationships between one or more independent variables and one or more dependent variables [28]. Moreover, the most common standard ranges that are used for evaluating the fit between a model and data and testing the accurateness of the model formed [29] .

Table 1: Recommendations for Model Evaluation: Some Rules of Thumb (Schermelleh-engel et al., 2003)

Fit Measure	Good Fit	Acceptable Fit
χ^2	$0 \leq \chi^2 \leq 2\,df$	$2df \leq \chi^2 \leq 3\,df$
p value	$0.05 \leq p \leq 1.00$	$0.01 \leq p \leq 0.05$
χ^2/df	$0 \leq \chi^2/df \leq 2$	$2 \leq \chi^2/df \leq 3$
RMSEA	$0 \leq RMSEA \leq 0.05$	$0.05 \leq RMSEA \leq 0.08$
p value for the test of close fit (*RMSEA* < 0.05	$0.1 < p \leq 1.00$	$0.05 < p \leq 0.10$
Confidence interval (CI)	Close to RMSEA, left boundary of CI = 0.0	Close to RMSEA
SRMR	$0 \leq SRMR \leq 0.05$	$0.05 < SRMR \leq 0.10$
NFI	$0.95 \leq NFI \leq 1.00^a$	$0.90 \leq NFI \leq 0.95$
NNFI	$0.97 \leq NNFI \leq 1.00^a$	$0.95 \leq NNFI \leq 0.97^O$
CFI	$0.97 \leq CFI \leq 1.00$	$0.95 \leq CFI \leq 0.97^O$
GFI	$0.95 \leq CFI \leq 1.00$	$0.90 \leq CFI \leq 0.95$
AGFI	0.90≤ AGFI≤ 1.00, Close to GFI	0.85≤ AGFI< 0.90, Close to GFI
AIC	Smaller than AIC for comparison model	
CAIC	Smaller than CAIC for comparison model	
ECVI	Smaller than ECVI for comparison model	

3.1. Population and sample

The population of the study was comprised of eight graders (form two) in Malaysia educational system. This study involved 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 stratified two-stage sampling [30]. Whereas the first stage included the selection of the schools using a random sampling from all the secondary schools in Malaysia. For every participated school, a single classroom of eighth grade students was selected at random in the second stage. Students from these selected classes were asked to complete pupils' questionnaires. Details of the sampling procedure, schools environment, background information of the students, background information of the parents, science questions and science achievement can be found in TIMSS reports [31].

3.2. Measured variables

Items were selected for structural equation modeling 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 students' achievement in science were 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. The definitions and corresponding items in the TIMSS questionnaires of each variable are introduced below. A detailed list of the items selected to be the indicators for each variable in this study is shown below.

(i) Parental involvement

This variable describe the participation of parents in their children's education with the aim of encouraging academic achievements of children. Three items (preceded by their identifier codes) from the background questionnaire were used to compose the scale: "How often do your parents ask what you learned in school?" (BSBG11A), "How often do you talk about school homework with your parents at home?" (BSBG11B) and "How often do your parents make sure that you set aside time for your homework?" (BSBG11C).

(ii) School disciplinary

This variable reflects feeling comfortable and safe at school. Three items from the background questionnaire were used to compose the scale: "During this year, how often were you made fun of or called names at school?" (BSBG13A), "During this year, how often did someone spread lies about you at school?"(BSBG13C) and "During this year, how often were you hit or hurt by other student(s) at school?" (BSBG13E).

(iii) Attitudes towards science

This variable represents students' emotional orientation or personal opinions toward learning science. Three items from the background questionnaire formed the scale: "How much do you agree that you enjoy learning science?" (BSBS17A), "How much do you agree that you learn many interesting things in science?" (BSBS17E) and " How much do you agree that you like science?" (BSBS17F).

(iv) Science achievement

This measure reflected the comparative grade-level performance of students on the science tests. The TIMSS 2011 science achievement tests covered the content domains for earth science. There are 14 sets of science achievement booklet test which contains 245 items. Each set booklet contains about 12 to 18 items, approximately half the items were constructed-response and half were multiple-choice. However, students are not required to answer all items. Instead, they are requested to complete only one set booklet. The TIMSS test was designed to measure knowledge and understanding of students in science.

3.3. Analyse technique

Data analysis was based on the SEM approach to test hypothesized models. 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 [32]. 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 unlike [33]. All analyses were performed using AMOS18.

4. Results

The results of the analyses are reported for the structural model and comparison between direct model and indirect model.

4.1. Structural model analysis

Once the measurement model has been confirmed, the fit of the structural path model posited can be evaluated and compared Figure 1. The factor structure confirmed in the measurement model will be used as the foundation for the structural model Figure 1. That is, the four latent constructs of parental involvement, school disciplinary, attitudes towards science and science achievement, together with their respective measurement indicators, will be incorporated into the structure of the path model to be evaluated. For this structural analysis, there are 42 parameters to be estimated. This model therefore has 48(90 – 42) degrees of freedom, and yielded a significant chi-square value, $\chi 2$ (N=5535, df=48) = 755.89, $p < 0.05$.

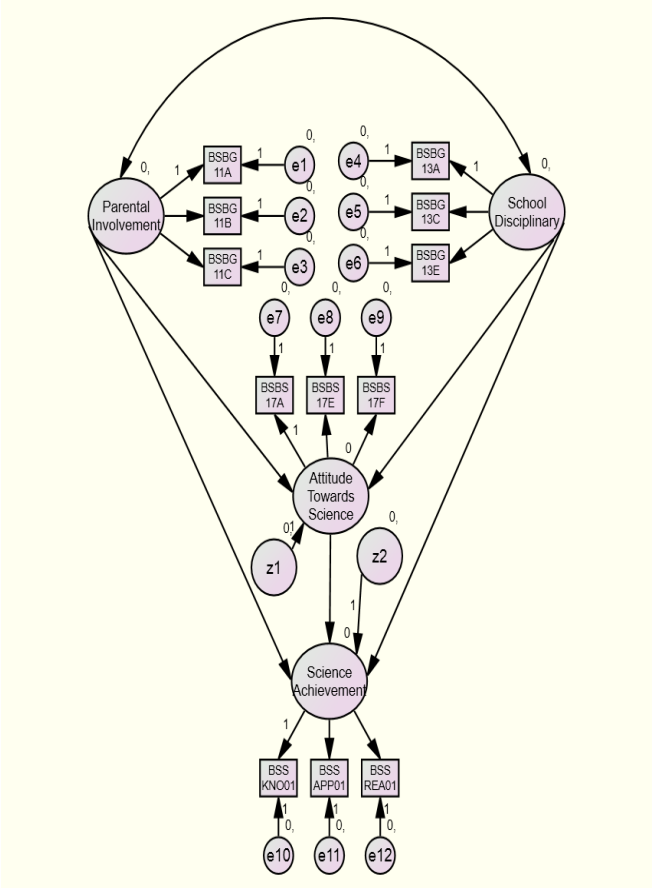

Fig. 1: Structural Model

4.1. Assessment on direct model and indirect model

The results of the direct model assessment included standardized direct, indirect and total effects. The direct effects are the same coefficient as for standardized regression weights, whereas the indirect effects are calculated using the multiplication rule; a compound path is the product of the legs of its direct paths. The total effects are calculated by the sum of direct and indirect effects.
According to Table 2, it is found that there were direct positive influences between; (i) Parental Involvement and Attitude Towards Science (β= 0.231) and (ii) Parental Involvement and Science Achievement (β= 0.033). However, it is found that there was direct negative influence between; (i) School Disciplinary and Attitude Towards Science (β= -0.011), (ii) Attitude Towards Science and Science Achievement (β= -0.261) and (iii) School Disciplinary and Science Achievement (β= -0.017). By referring to the indirect effect of the variables, it is found that there were indirect negative influences between; Parental Involvement and Science Achievement (β= -0.060) with the total effect of -0.027.

Table 2: Matrices of (a) Total Effects, (b) Direct Effects and (c) Indirect Effects

(a) Standardized Total Effects				
	School Disciplinary	Parental Involvement	Attitude Towards Science	Science Achievement
Attitude Towards Science	-.011	.231	.000	.000
Science Achievement	-.014	-.027	-.261	.000

(b) Standardized Direct Effects				
	School Disciplinary	Parental Involvement	Attitude Towards Science	Science Achievement

(b) Standardized Direct Effects				
	School Disciplinary	Parental Involve-ment	Attitude Towards Science	Science Achieve-ment
Attitude Towards Science	-.011	.231	.000	.000
Science Achievement	-.017	.033	-.261	.000

(c) Standardized Indirect Effects				
	School Disciplinary	Parental Involve-ment	Attitude Towards Science	Science Achieve-ment
Attitude Towards Science	.000	.000	.000	.000
Science Achievement	.003	-.060	.000	.000

Besides, the direct and indirect model also can be compared using multimodel analysis. The procedure contains two models; (1) the full direct model, which incorporates all identified paths linking the four factors, and (2) the indirect model, in which the two direct paths linking Parental Involvement to Attitude Towards Science and School Disciplinary to Attitude Towards Science will not be estimated. As both these models are nested and possess different degrees of freedom, their goodness-of-fit can be directly compared via multi-model analysis [34]. In the indirect model, the two direct paths linking Parental Involvement to Science Achievement and School Disciplinary to Science Achievement are constrained to zero. Constraining paths to zero is equivalent to those paths not being estimated[34]

Table 3: Direct and Indirect Models' (a) Chi-Square Goodness-of-Fit Indices, (b) Baseline Comparisons Indices and (c) RMSEA

(a) Chi-Square Goodness-of-Fit Indices					
Model	NPAR	CMIN	DF	P	CMIN/DF
Direct Model	42	755.895	48	.000	15.748
Indirect Model	40	761.476	50	.000	15.230
Saturated Model	90	.000	0		
Independence Model	24	39607.619	78	.000	507.790

(b) Baseline Comparisons Indices					
Model	NFI Delta1	RFI rho1	IFI Delta 2	TLI rho 2	CFI
Direct Model	.981	.969	.982	.971	.982
Indirect Model	.876	.970	.982	.972	.982
Saturated Model	1.000		1.000		1.000
Independence Model	.000	.000	.000	.000	.000

(c) RMSEA				
Model	RMSEA	LOW 90	HI 90	PCLOSE
Direct Model	.052	.048	.055	.255
Indirect Model	.051	.047	.054	.422
Independence model	.300	.298	.303	.000

Table 3 shows that Chi-Square Goodness-of-Fit Indices the value for Direct model and Indirect Model are $\chi 2(N=5355, df=48)=755.89$, $p<0.05$ and $\chi 2(N=5355, df=50)=761.47$, $p<0.05$. Besides that, the baseline comparisons fit indices of NFI, RFI, IFI, TLI and CFI for direct model are above 0.9 (value range from 0.969 to 0.982), while these indices for the indirect model are above 0.8 (value range from 0.876 to 0.982).These values indicate that both the hypothesized direct and indirect models fitted the observed variance-covariance matrix well [34]. The RMSEA values for both the direct model and indirect model respectively were 0.052 and 0.051. Values ranging below 0.08 are acceptable [27, 35].

5. Discussion

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. This study was in line with finding by [36] found that parental involvement has a positive correlation with student achievement. This means that the higher the parents' involvement in supporting student learning at home, the more positive student attitudes toward learning [37].

Parents who practicing concerned attitude towards the student's academic progress at home can create a culture of science in the family environment [38]. Attitude of parents who always emphasized education of children is the driving force for parents involved in any form of education, especially at home [39] Parenting practice who 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 concern and keep abreast of their children's education development [37].

Further, these findings are also supported by Yong and Rahman [40] found that parents should monitor their child's academic progress through report cards, progress reports, and keep in touch with the teacher. This allows parents to keep abreast of child's academic progress by providing space for children deliver information about their education freely. Children need support from parents not only as a mentor but as a friend in case of problems [19].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 involved directly or indirectly in children learning activities.

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 interested in science, which shows that attitudes towards science are important in determining student achievement in science. However, the results showed that students' attitudes to science was high but student achievement is low. Most students are only interested in science and are unable to obtain a high score in TIMSS 2011 science test. This findings are also consistent with the findings of the TIMSS 1999 study conducted by researchers like [41] in Turkey. Although these findings seem to contradict the study and the usual assumption, but 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 [42]. 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 which science achievement is measured through examination [43]. Students placed more importance on science achievement in examinations. This causes students more focus on memorizing rather than understanding the basic concepts of science [41].

Previous studies have found enjoyment in science can be seen when students feel excited [44] and having fun while doing science learning activities [45]. In addition, the enjoyment of science can be described through fun learning science in the classroom, engage in the lab, talking about science, watch science programs and reading materials science oriented [42]. But in this study, the students feel that they enjoy and feel good with science, however they still cannot master the science as a whole because they do not understand the basic concepts of science and not proficient in science activities [41, 46]. This was apparent from the findings of the 2011 TIMSS results showed Malaysian student scores in science below the minimum scores as determined by the International Association for the Evaluation of Educational Achievement (IEA).

The tested model also showed that there is no relationship between school discipline with attitudes towards science and school discipline with science achievement of students. Furthermore, the school discipline does not contribute to the attitudes towards science and science achievement of students in TIMSS 2011. The study also found that the excellence of the students do not rely heavily on parental involvement in education. These findings clearly show that the family context more conducive and positive and dominant role in generating academic excellence. This also means the involvement of parents by simply presenting themselves and be involved with activities arranged by the school were insufficient. Even without parent involvement like this, children can still excel in their studies.

6. 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 direct 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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