



CONFIRMING THE MEDIATION EFFECT OF A STRUCTURAL MODEL BY USING BOOTSTRAP APPROACH: A CASE STUDY OF MALAYSIAN 8TH GRADE STUDENTS' MATHEMATICS ACHIEVEMENT

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ABSTRACT

The performance of Malaysian students in Trends In Mathematics and Science Study (TIMSS) was not up to par. The rank of Malaysian students in the assessment is the bottom one third, not the top. However, there are still a very low number of studies have been conducted with the TIMSS finding. This study intends to a) confirm items reliability included in the study(for Malaysian students), b) confirm the significance of latent exogenous constructs toward latent endogenous construct and c) confirm the type of mediation exist in the structural model. Secondary data obtained from TIMSS 2011 database has been used in this study. Items have been grouped into latent exogenous constructs; school, teacher, motivation, self-confidence; latent mediator construct; attitude and latent endogenous construct; achievement. From the analysis, it is found that only a few items included are reliable to represent respective constructs. Furthermore, it is explored that all latent exogenous constructs have significant direct effects toward latent endogenous construct. And lastly, it has also been confirmed that, all latent exogenous constructs except school latent construct have indirect effects toward endogenous latent construct; students' achievement through the mediator latent construct; attitude.

Keywords: SEM, CFA, Discriminant analysis, Mediation, Path analysis, Bootstrap, Structural model, TIMSS.

Contribution/ Originality

This study is one of very few studies which have investigated the usefulness of bootstrap approach in confirming the type of mediation exist in a model. Commonly, bootstrap approach is only used when the data is small and/or the multivariate normal distribution is not fulfilled.

1. INTRODUCTION

Structural Equation Modeling or also known as SEM has gained popularity among researchers, academicians and students nowadays. It is due to its flexibility and generality besides the ability to generate an accurate and precise estimation in making prediction. SEM analysis goes through the steps of model specification, data collection, model estimation, model evaluation and also model modification (Zainudin, 2012). SEM enables researcher to modify the structural and measurement models. Structural model may consist of mediator and/or moderator. Mediation analysis is an analysis that is commonly performed in order to identify the type of mediation

exists in the model. However, in this study, an extension analysis known as bootstrap approach has been used to confirm the type of mediation exists in the model.

2. SAMPLE OF THE STUDY

The sample of this study is obtained from Trends in International Mathematics and Science Study (TIMSS) international database where Malaysia respondents have been selected as the case study. Respondents in this study are normally selected through a two stage stratified cluster sampling technique; cluster sampling for the first stage, school sampling for the second stage and class sampling for the third stage.

3. METHODOLOGY

3.1. Confirmatory Factor Analysis (CFA)

CFA is a special form of factor analysis, most commonly used in social research. It is different compared to Exploratory Factor Analysis (EFA) since it is used to test whether measures of a construct consistent with a researchers' understanding of the nature of that construct (or factor). As such, the objective of CFA is to test whether the data fit a hypothesized measurement model.

CFA is a crucial part for the measurement model in SEM that is used to obtain the acceptable model fit before modeling the structural model. There are two methods in running CFA; Individual CFA and Pooled CFA (Chong *et al.*, 2014). To achieve unidimensionality of construct, the factor loading of every all items must be higher or equal to 0.6 (Hair *et al.*, 2006). Model fit measures could be obtained to assess how well the proposed model captured the covariance between all the items or measures in the model. All redundant items exist in latent constructs should be either removed or constrained. Factor Loading, Absolute, Incremental and Parsimonious fitness indexes must achieve the acceptance level. According to Zainudin (2012) the fitness indices estimations are as follows:

Table-1. Fitness Indexes

Name of Category	Name of Index	Acceptance Level	Literature
Factor Loading	Standardized Regression Weight	Weight ≥ 0.6	Hair <i>et al.</i> (2006)
Absolute Fit	Chi-Square	$P > 0.05$	Wheaton <i>et al.</i> (1977)
	RMSEA	RMSEA < 0.08	Browne and Cudeck (1993)
	GFI	GFI > 0.9	Joreskog and Sorbom (1984)
Incremental Fit	AGFI	AGFI > 0.9	
	CFI	CFI > 0.9	
	TLI	TLI > 0.9	Bentler and Bonett (1980)
	NFI	NFI > 0.9	Bollen (1989)
Parsimonious Fit	Chi-Square/ Degree of Freedom	ChiSq/Df < 5.0	

Source: Zainudin (2012)

3.2. Discriminant Validity

Discriminant validity is a degree to which scores on a test do not correlate with scores from other tests that are not designed to assess the same variable. Correlation coefficients between measures of a construct and measures of conceptually different variables are usually given as evidence of discriminant validity (Lewis-Beck *et al.*, 2004). It is a procedure of linking exogenous constructs in a model to examine whether they are highly correlated to each other or otherwise. Exogenous constructs must be independent to each other, in which, the correlation value between them should not exceed 0.85 in order to achieve discriminant validity of construct (Zainudin, 2012). If the correlation(s) is/are higher than 0.85, one of the highly correlated constructs must be removed or multi-collinearity

problem is exist. However, proper analysis and investigation need to be adopted first before removing any constructs.

3.3. Path Analysis

Path Analysis may consist of simple or multiple statistical regression models. Besides the ability to determine the causal path, it is able to identify the type of mediation exist in a model. The difference between path analysis and conventional regression is the causal path in the model can be modified according to the researcher desire. According to Zainudin (2012) there are three types of mediation:

- i. Complete mediation: Occur when the independent variable links towards the dependent variable only through mediator variable and there is no direct effect of independent variable towards dependent variable.
- ii. Partial mediation: Occur when independent variable links towards the dependent variable through mediator variable and there is also a direct effect of independent variable towards dependent variable.
- iii. No mediation: Occur when independent variable does not link to the dependent variable through mediator variable but has a direct effect towards dependent variable.

3.4. Bootstrap

Bootstrap is one of the crucial parts in modeling structural model when it comes to confirm the type of mediation. In addition, it also allows researcher to assess the stability of parameter estimates that can be applied when the assumptions of large sample size and multivariate normality may not hold. In order to perform this approach, two models need to be built; one with the existence of mediator construct and the other, otherwise. The type of mediation should then be confirmed based on the direct and indirect effects reported.

4. RESULTS

4.1. Pooled Confirmatory Factor Analysis (Pooled CFA) and Discriminant Validity

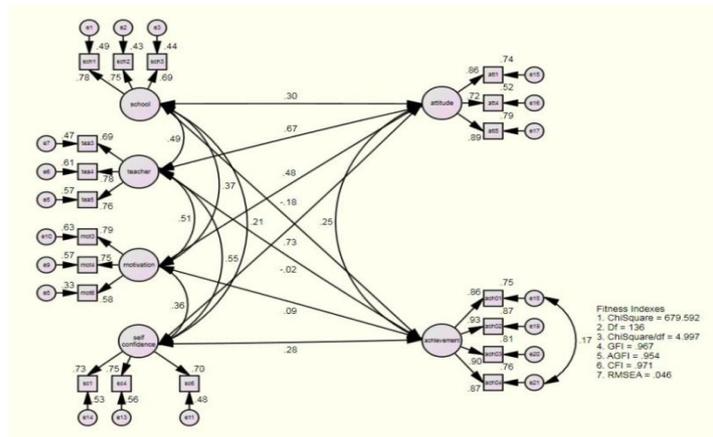


Figure-1. Pooled CFA model

Source: AMOS Graphic Output

Table-2. Model Fitness Indexes

Name of Category	Name of Index	Index value	Required level
1. Absolute Fit	RMSEA	0.046	< 0.08
	GFI	0.967	> 0.90
2. Incremental Fit	CFI	0.971	> 0.90
3. Parsimonious Fit	Chisq/df	4.997	< 5.0

Source: AMOS Graphic Output

Figure 1 and Table 2 show that the fitness indexes of the model achieved the required level after the Pooled CFA has been conducted. The factor loading of all items toward its' respective constructs are greater than 0.6, therefore it can be concluded that the models' unidimensionality is achieved. Besides that, all latent exogenous constructs are correlated with the correlation strength of less than 0.85. Therefore, no multi-collinearity problem exists and the discriminant validity is achieved.

Table-3. Reliable items obtained (Malaysian students)

Construct	Item	Statements
School	Sch1	I like being in school
	Sch2	I feel safe when I am at school
	Sch3	I feel like I belong at this school
Teacher	Tea3	My teacher is easy to understand
	Tea4	I am interested in what my teacher says
	Tea5	My teacher gives me interesting things to do
Motivation	Mot3	I need to do well in mathematics to get into the <university> of my choice
	Mot4	I need to do well in mathematics to get the job I want
	Mot6	It is important to do well in mathematics
Self-Confidence	Sc1	I usually do well in mathematics
	Sc4	I learn things quickly in mathematics
	Sc6	I am good at working out difficult mathematics problems
Attitude	Att1	I enjoy learning mathematics
	Att4	I learn many interesting things in mathematics
	Att5	I like mathematics

Source: AMOS Graphic Output

Table 3 shows the reliable items for Malaysian students that have been obtained for measurement model through the Pooled CFA. Initially, school, teacher, motivation, self-confidence and attitude constructs consist of nine(9), eight(8), six(6), seven(7) and five (5) items respectively. The other items were dropped from the model for having factor loadings of low than 0.6. The low reliability of the items may jeopardize the model fit indexes measurement, hence were dropped from the model.

4.2. Path Analysis

In bootstrap approach, two structural models have been constructed; one with the absence of mediator construct and the other one with the existence of mediator construct.

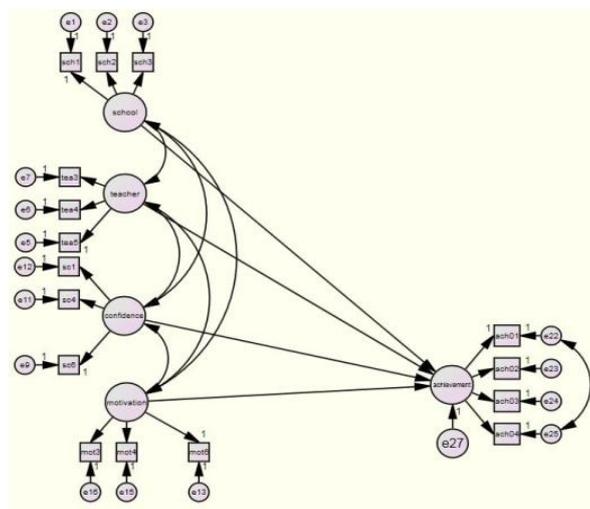


Figure-2. Model in the absence of mediator latent construct
Source: AMOS Graphic Output

Figure 2 shows a constructed model in the absence of mediator latent construct. This model is constructed so that the direct effect of exogenous latent constructs toward endogenous latent construct could be observed.

Table-4. Standardized Regression Weights

Relationship	Estimate
Achievement <--- School	-.206
Achievement <--- Teacher	-.187
Achievement <--- Confidence	.379
Achievement <--- Motivation	.095

Source: AMOS Graphic Output

Table-5. Regression Weights

Relationship	Estimate	S.E.	C.R.	P
Achievement <--- School	-.186	.019	-9.675	***
Achievement <--- Teacher	-.121	.017	-7.265	***
Achievement <--- Confidence	.270	.016	17.362	***
Achievement <--- Motivation	.114	.024	4.843	***

Source: AMOS Graphic Output

Table 4 and Table 5 show the direct effect and the significance of exogenous latent constructs toward endogenous latent construct in the absence of mediator latent construct. All exogenous latent constructs are identified to have significant influence toward the endogenous latent construct. This finding indicates that school, teacher, self-confidence and motivation contribute in affecting the students' achievement. It has been also found that two exogenous latent constructs; school and teacher have negative estimates value.

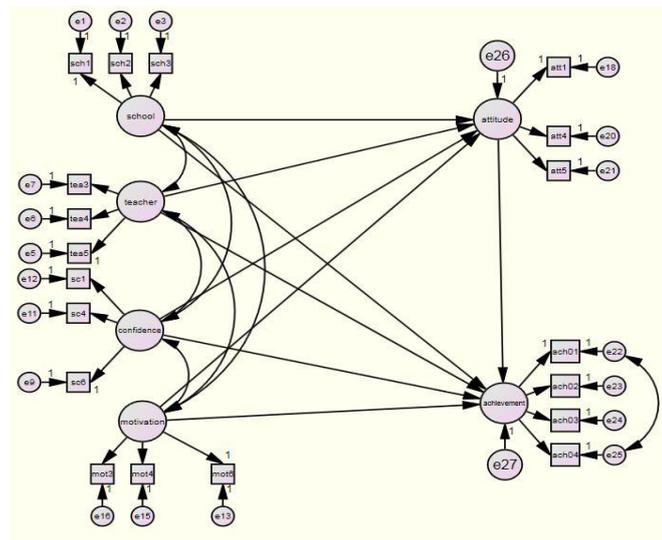


Figure-3. Model in the existence of mediator latent construct

Source: AMOS Graphic Output

Figure 3 shows a constructed model in the existence of mediator latent construct. This model is constructed so that the direct and indirect effects of exogenous latent constructs toward endogenous latent construct could be observed.

Table-6. Standardized Regression Weights

Relationship	Estimate
Attitude <--- Teacher	.330
Attitude <--- Motivation	.136
Attitude <--- Confidence	.500
Attitude <--- School	-.023
Achievement <--- School	-.198
Achievement <--- Teacher	-.284
Achievement <--- Confidence	.246
Achievement <--- Motivation	.059
Achievement <--- Attitude	.275

Source: AMOS Graphic Output

Table-7. Regression Weights

Relationship	Estimate	S.E.	C.R.	P
Attitude <--- Teacher	.314	.018	17.520	***
Attitude <--- Motivation	.241	.028	8.650	***
Attitude <--- Confidence	.574	.021	28.000	***
Attitude <--- School	-.032	.023	-1.426	.154
Achievement <--- School	-.178	.019	-9.501	***
Achievement <--- Teacher	-.181	.018	-10.356	***
Achievement <--- Confidence	.179	.020	9.095	***
Achievement <--- Motivation	.069	.023	2.984	.003
Achievement <--- Attitude	.177	.019	9.528	***

Source: AMOS Graphic Output

Table 6 and Table 7 show the direct effect and the significance of exogenous latent constructs toward endogenous latent construct in the existence of mediator latent construct. From the table, it is found that all exogenous latent constructs except school latent construct have significant influence toward mediator latent construct. It is also found that all exogenous latent constructs have significant influence toward endogenous latent construct in the presence of latent mediator construct.

4.3. Bootstrap Approach

Table-8. Standardized Indirect Effects - Two Tailed Significance (BC)

	motivation	confidence	teacher	School	attitude	achievement
Attitude
Achievement	.002	.002	.002	.247

Source: AMOS Graphic Output

The standardized Indirect Effect table above shows that exogenous latent constructs except school have partial mediation effects toward achievement through attitude.

5. CONCLUSIONS AND DISCUSSION

From the Pooled Confirmatory Factor Analysis finding, it has been found that most of the items included in the study have factor loadings of low than 0.6. Hence, these items were dropped from the model because they are not reliable and may jeopardize the model estimates.

In the discriminant validity test, it has been explored that the correlation of all latent constructs are below 0.85. The low correlations indicate that all constructs are independent to each other. In other word, there is no constructs are measuring the same thing. In achieving discriminant validity, redundant items in achievement latent construct; ach01 and ach04 have been also constrained.

The path analysis has been conducted in the absence and existence of mediator latent construct. In the absence of mediator latent construct, all exogenous latent constructs show significant direct effects toward endogenous latent construct. This indicates that school, teacher, self-confidence and motivation have direct contribution toward students' achievement. In the existence of mediator latent construct, all exogenous latent constructs show significant indirect effects toward endogenous latent construct through mediator latent construct except for school. This indicates that teachers, self-confidence and motivation have indirect contributions or partial mediation toward students' achievement through attitude while there is no mediation occurs for school construct. In addition, this finding also indicates that teacher, self-confidence and motivation have significant contributions toward students' attitude.

However, there are two types of effect exist in the model; positive and negative effects. School and teacher have negative effects toward students' achievement, the same goes to the effect of school towards attitude. The negative effects indicate that increase in unit of school and teacher will decrease in the students' attitude and/or achievement. For example, the more a student likes his/her mathematics teacher, the lower the achievement of the student in mathematics will be.

Table-9. Summary table

Relationship			Direct without mediator	Direct with mediator	Indirect Effect
School	Attitude	Achievement	-.206 (***)	-.199 (***)	.247
Teacher	Attitude	Achievement	-.187 (***)	-.284 (***)	.002
Confidence	Attitude	Achievement	.379 (***)	.245 (***)	.002
Motivation	Attitude	Achievement	.095 (***)	.059 (.003)	.002

In the bootstrap approach, the indirect effects of exogenous latent constructs toward endogenous latent construct have been confirmed. The summary table shows that all exogenous latent constructs have significant effects toward endogenous latent construct; achievement. However, for indirect effect result, all exogenous latent constructs except school have indirect effect toward achievement through attitude. This finding concludes that the effects obtained in the path analysis have been confirmed.

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