International Journal of Advances in Applied Sciences (IJAAS)
Vol. 3, No. 4, December 2014, pp. 172~177
ISSN: 2252-8814

Modeling the Influential Factors of 8th Grades Student's Mathematics Achievement in Malaysia by Using Structural Equation Modeling (SEM)

Ahmad Nazim
Department of Mathematics, Faculty of Science and Technology, Universiti Malaysia Terengganu, Malaysia

Article Info

Article history:

Received Sep 11, 2014
Revised Nov 15, 2014
Accepted Nov 26, 2014

Keyword:

Discriminant Analysis
Mediation
SEM
Structural Equation Modeling
TIMSS

ABSTRACT

This research demonstrates the application of Structural Equation Modeling (SEM) method in order to obtain the best fit model for a more efficient and accurate inter-relationship among variables findings and interpretation. For the purpose of this study, secondary data of Trends in International Mathematics and Science Study (TIMSS) was used. The questionnaire were distributed by using two stage stratified cluster sampling technique to 5733 eighth grades students in Malaysia. A Confirmatory Factor Analysis (CFA), Discriminant Validity and Path Analysis had been conducted to obtain the best fit model of SEM. At the end of the study, a best fit model will be obtained for a better accuracy and precision estimation in further analysis.

Corresponding Author:

Ahmad Nazi,
Department of Mathematics, Faculty of Science and Technology,
Universiti Malaysia Terengganu,
21030 Kuala Terengganu, Malaysia.
Email: naxeem007@gmail.com

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 can 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. SEM is a unique method because the researcher can modify the structural model in order to increase the model fitness.

Ordinary Least Square or also known as OLS is one of the method used in making prediction and estimation. Same as SEM, it is used to analyze the relationships among (independent, dependent and mediator) variables. Researchers usually use OLS in Regression Analysis and Correlation Analysis in which also can be performed using SEM.

However, problems exist during data analysis by using OLS is when multiple response items are used in measuring the variables. What researchers, academician or students normally do in Ordinary Least Square (OLS) method with this problem is by computing the mean response of these items to measure the variables which is theoretically inefficient and will lead to inaccurate findings later on. SEM is better than OLS because it has the ability to calculate the affect of items under each variables individually besides it takes into consideration the structure of mean, variance and covariance simultaneously in its analysis for a more efficient and accurate findings.

A secondary data obtained from Trends in Mathematics and Science Study (TIMSS) will be used to apply SEM method in order to obtain a best fit model for further analysis.

2. RESEARCH METHOD

The population of the study is defined as the eighth grades (form two) students in Malaysia. Our target population is eighth grades students in Malaysia. A value of 5733 respondents was randomly chosen from 180 randomly chosen schools in Malaysia. In this case study, eighth grades student's attitude towards Mathematics acts as mediating variable and achievement in Mathematics examination acts as dependent variable for this study.

Data were obtained from the Trends in International Mathematics and Science Study (TIMSS) international database. Respondents were normally selected through a two stage stratified cluster sampling technique in which consist of cluster sampling for the first stage, school sampling for the second stage and class sampling for the third stage. The questionnaire consists of four independent variables which are; school environment, teacher's characteristics, student's self-confidence in Mathematics and student's motivation in Mathematics. It also includes student's attitude in Mathematics which acts as mediating variable and student's Mathematics achievement as the dependent variable. The data mining software SPSS PASW version 18.0 and SPSS AMOS were used for the purpose of building model. Several analysis used in this study are Confirmatory Factor Analysis (CFA), Discriminant Validity, Path Analysis, Structural Equation Modeling (SEM) and Chi Square test.

Confirmatory Factor Analysis (CFA) is a special form of factor analysis, most commonly used in social research (Ahmad Nazim, 2013). It is different compared to Exploratory Factor Analysis (EFA) since it is used to test whether measures of a construct consistent with a researcher's 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. Model fit measures could then be obtained to assess how well the proposed model captured the covariance between all the items or measures in the model (Zainudin, 2012). All redundant items exist in a latent construct will be either removed or constrained (Ahmad Nazim, 2013). Model fitness estimations are as follows:

Table 1. Model fitness estimation

Name of Category	Name of Index	Level of Acceptance	Literature
Factor Loading	Standardized Regression Weight	Weight > 0.5	Heir et al (2006)
Absolute Fit	Chisq	P > 0..05	Wheaton et al. (1977)
	RMSEA	RMSEA < 0.08	Browne and Cudeck (1993)
	GFI	GFI > 0.9	Joreskog and Sorbom (1984)
Incremental Fit	AGFI	AGFI > 0.9	Tanaka and Huba (1985)
	CFI	CFI > 0.9	Bentler (1990)
	TLI	TLI > 0.9	Bentler and Bonett (1980)
	NFI	NFI > 0.9	Bollen (1989)
Parsimonious Fit	Chisq/df	Chisq/df < 5.0	Marsh and Hocevar (1985)

Discriminant validity is the degree to which scores on a test do not correlate with scores from other tests that are not designed to assess the same construct. Correlation coefficients between measures of a construct and measures of conceptually different constructs are usually given as evidence of discriminant validity. If the correlation coefficient is high (>0.85), then the discriminant validity is considered as weak, depending on the theoretical relationship and the magnitude of the coefficient (Zainudin, 2012). On the other hand, if the correlations are low to moderate, this demonstrates that the measure has discriminant validity.

$$\text{Correlation coefficient} = \frac{r_{xy}}{\sqrt{r_{xx} \cdot r_{yy}}}$$

Where:
r_{xy} = correlation between x and y
r_{xx} = reliability of x
r_{yy} = reliability of y

Path Analysis can test the significance of mediator variable in linking independent variables to dependent variable or simply called as mediation test. It can determine the existence of direct and indirect effect of independent variable towards dependent variable. Usually in SPSS/ANOVA, the conventional regression needs to be analyzed separately in order to determine the mediating effect. However in AMOS, the regression equations can be run simultaneously in one diagram. There are three types of mediation which are:

a) 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.

b) 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.

c) No mediation: Occur when independent variable does not link to the dependent variable through mediator variable but has a direct effect towards dependent variable.

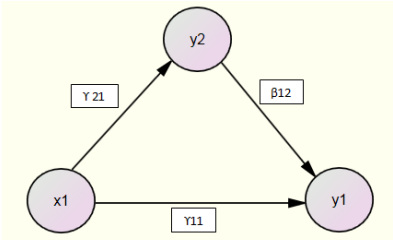

Figure 1. Mediation structure

Figure above shows the example of mediation test. x1 acts as independent variable, y2 acts as mediator variable and y1 acts as dependent variable. In mediation test, the direct/indirect effect of x1 towards y1 can be determined.

The Structural Equation Modeling or popular known as SEM is a second generation statistical analysis techniques developed for analyzing the inter-relationships among multiple variables in a model. The relationships among variables could be expressed in a series of single and multiple regression equations. SEM technique employs the combination of quantitative and the correlational or causal assumptions into the model (Zainudin, 2012). SEM can indirectly estimates the items under latent construct individually. Latent construct is the variable which can't be measure directly since it is only a hypothetical concept of a research. Latent construct is also known as unobserved variables, it is measured using a set of items in a questionnaire. The use of SEM is also able to model the relationship among these constructs and analyze them simultaneously.

3. RESULTS AND ANALYSIS

3.1. Confirmatory Factor Analysis (CFA)

Table 2. Confirmatory Factor Analysis Summary table

Construct	Item	Factor Loading	Cronbach Alpha	CR	AVE
School	sch1	.679	0.712	0.714	0.6740
	sch2	.654			
	sch3	.689			
Teacher	tea1	.570	0.792	0.795	0.6995
	tea3	.704			
	tea4	.802			
	tea5	.722			
Confidence	sc1	.727	0.710	0.770	0.726
	sc4	.711			
	sc6	.740			
Motivation	mot1	.491	0.767	0.7751	0.633
	mot3	.823			
	mot4	.762			
	mot5	.566			
	mot6	.523			
Attitude	att1	.852	0.826	0.8409	0.7463
	att3	.529			
	att4	.696			
	att5	.908			
Achievement	ach01	.861	0.990	0.9402	0.8925
	ach02	.936			
	ach03	.900			
	ach04	.873			

Table 2 shows the Factor Loading, Cronbach Alpha, Critical Ratio (CR) and Average Variance Extracted (AVE) values of each latent constructs. According to Zainudin (2012), the factor loading for a newly developed scale must be higher or equal to 0.5. In this study, items with factor loading value of lower than 0.5 were dropped one at a time (starts with the lowest value) from its' constructs until the unidimensionality, parsimonious, incremental and absolute fits are achieved. In this study, pooled CFA was applied since a few constructs have less than four items in its construct which lead to identification problem. After all items of less than 0.5 were decided to be removed or kept in its construct, the Modification Indices (MI) of items under each latent constructs were checked. If the MI indices of a pair of items are greater than 15, the items need to be set as 'free parameter estimate' or constrained to avoid insignificant of model fitness later on. In this study, items (ach01 and ach04, mot1 and mot5, mot1 and mot6, mot3 and mot5) have MI value of greater than 15 and were constrained Besides that, items att2, sc3 and mot2 were removed because have an extreme correlation with items att3, sc5 and mot1 with MI values of 753.8, 566.156 and 252.866 respectively.

As for measurement values, all constructs have achieved the minimum estimation required which are 0.70 for Cronbach Alpha, 0.60 for CR and 0.50 for AVE. Therefore, it can be concluded that Convergent Validity (AVE ≥ 0.5), Internal Reliability (Cronbach Alpha ≥ 0.6) and Construct Reliability (CR ≥ 0.60) of all constructs had been achieved.

Table 3. The Latent Constructs Fitness Indexes

Construct	Parsimonious Fit	Incremental Fit		Absolute Fit		
	Chisq/Df	TLI	CFI	AGFI	GFI	RMSEA
School	4.273	.993	.998	.996	.999	.025
Attitude	3.966	.993	.998	.989	.998	.046
Confidence	3.277	.997	.999	.997	.999	.021
Motivation	2.956	.997	.999	.997	1.000	.020
Teacher	4.904	.995	.998	.994	.999	.031
Achievement	3.156	.988	.998	.962	.996	.046

Table 3 shows the fitness indices of all latent constructs in the model. All constructs have a ChiSq/df value of less than 5.0, therefore the Parsimonious fit had been achieved. Constructs also have TLI, CFI, AGFI and GFI values of higher than 0.9 and RMSEA value of less than 0.05. Therefore, Incremental and Absolute fitness also had been achieved. It can be concluded that all fitness indexes required in a model had been achieved.

3.2. Discriminant Analysis

Figure 2 shows the strength of correlation between all constructs in the model. All constructs have correlations of less than 0.85. It can be concluded that discriminant validity had been achieved and no construct need to be dropped from the model.

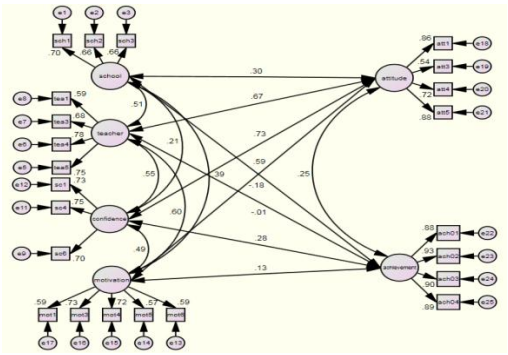

Figure 2. The Standardized Regression Weight

3.3. Path Analysis

The Table 4 shows the value of regression weight for the independent latent constructs toward attitude (mediating) and achievement (dependent) variables. All independent latent constructs have significant effect towards both attitude and achievement variables thus have partial mediation role in linking

to achievement except for school variable which is not significantly link to attitude. Therefore, school variable has no mediation in linking with achievement.

Table 4. Unstandardized Regression Weight of model

			Estimate	S.E.	C.R.	P
attitude	<---	teacher	.333	.021	16.119	***
attitude	<---	motivation	.301	.031	9.779	***
attitude	<---	confidence	.542	.022	25.074	***
attitude	<---	school	-.031	.022	-1.390	.165
achievement	<---	school	-.181	.019	-9.714	***
achievement	<---	teacher	-.176	.018	-9.793	***
achievement	<---	confidence	.167	.020	8.297	***
achievement	<---	motivation	.098	.025	3.915	***
achievement	<---	attitude	.183	.019	9.652	***

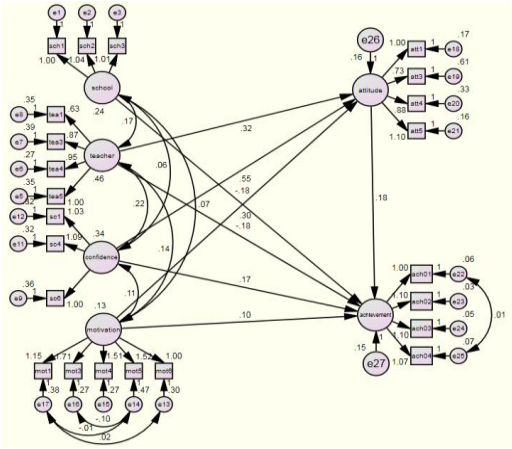

Figure 3. Final constructs model

Table 5. Model Fitness

Model	CMIN	DF	CMIN/DF	RMSEA
Default model	944.218	257	3.674	0.044

The ChiSquare/df and RMSEA value indicate that the model has achieve a good fit model since the ChiSquare/df value is less than 5.0 and RMSEA value is less than 0.08.

4. CONCLUSION

From the analysis that had been conducted for SEM method, in Confirmatory Factor Analysis (CFA) and pooled Confirmatory Factor Analysis (CFA) processes, redundant items had been either removed or constrained in the model to achieve unidimensionality. At the end of the processes, convergent validity, internal reliability and constructs reliability of all constructs had been achieved. In addition, discriminant validity of the model was achieved since the correlations between constructs in the model are below 0.85. In path analysis, the type of mediations exist between constructs were determined and re-specified in order to obtain the actual influential structural model. At the end of the modelling process, the Chi-Square/df value was obtained and it shows a value of 3.674 which conclude that the model is now in its best structure for further analysis for a more efficient and accurate inter-relationship among variables findings and interpretation.

REFERENCES

[1] Ahmad Nazim, *et al.*, "A Comparison Between Ordinary Least Square (OLS) And Structural Equation Modeling (SEM) Methods In Estimating The Influencial Factors Of 8th Grades Student's Mathematics Achievement In Malaysia," *International Journal of Scientific and Engineering Research (IJSER)*, 2013, Vol. 4, No. 7.

[2] Ahmad Nazim, *et al.*, "Assessing The Unidimensionality, Reliability, Validity And Fitness Of Influential Factors Of 8th Grades Student's Mathematics Achievement In Malaysia," *International Journal Of Advanced Research Mathematics (IJOARM)*, 2013, Vol. 1, No. 5.

[3] Ahmad Nazim, *et al.*, "A Comparison between Individual Confirmatory Factor Analysis and Pooled Confirmatory Factor Analysis: An Analysis of Library Service Quality, A Case Study At A Public University Library in Terengganu," *International Journal Of Engineering, Science and Innovative Technology (IJESIT)*, 2014, Vol. 3, No. 1.

[4] Anderson, *et al.*, "Some Methods for Respecifying Measurement Models to Obtain Unidimensional Construct Measurement," *Journal of Marketing Research*, 1982, pp. 453-460.

[5] Anderson J. C., *et al.*, "Structural Equation Modeling in Practice: A Review and a Recommended Two-Step Approach," *Psychological Bulletin*, 1988, Vol. 103, No. 3, pp. 411-423.

[6] Baron R. M., *et al.*, "The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations," *Journal of Personality and Social Psychology*, 1986, Vol. 51, No. 6, pp. 1173-1182.

[7] Bentler P. M., "Comparative fit indexes in structural models," *Psychological Bulletin*, 1990, Vol. 107, pp. 238-246.

[8] Bollen K. A., "A new incremental fit index for general structural equation models," *Sociological Methods and Research*, 1989, Vol. 17, pp. 303-316.

[9] Byrne B. M., "Structural Equation Modeling with AMOS: Basic Concepts, Applications, and Programming, Mahwah," *New Jersey: Lawrence Erlbaum Associates*, 2001.

[10] Diana D. Suhr., "Citing Websites," *Exploratory or Confirmatory Factor Analysis*, 2001.

[11] Fornell, *et al.*, "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error," *Journal of Marketing Research*, 1981, pp. 39-50.

[12] Hair J. F., *et al.*, "Multivariate Data Analysis," *6th edition. Upper Saddle River*, New Jersey: Prentice Hall, 2006.

[13] Hu L., et al., "Cut off criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives," *Structural Equation Modeling*, 1999, Vol. 6, No. 1, pp. 1-55.

[14] Tanaka J. S., *et al.*, "A fit index for covariance structure models under arbitrary GLS estimation," *British Journal of Mathematical and Psychology*, 1985, Vol. 38, pp. 197-201.

[15] Zainudin A., "Research Methodology and Data Analysis," *5th Edition. Shah Alam: Universiti Teknologi MARA Publication Centre (UiTM Press)*, 2012.

BIOGRAPHY OF AUTHOR

Ahmad Nazim Aimran is a Statistician at National Population and Family Development Board of Malaysia. He pursued his Master's in Science (M.Sc.) Mathematics Statistics at Universiti Malaysia Terengganu (UMT), Malaysia and Bachelor in Science (B.Sc.) Statistics degree at Universiti Teknologi MARA (UiTM), Malaysia. Since Bachelor, he is an active facilitator for SPSS and AMOS workshop at the university. During the master's level, he is a demonstrator for Bachelor of Financial Mathematics students in time series and forecasting subject and an informal consultant for Social Sciences, Statistics, Economic and other Master's and PhD students of UMT. His main ability is in Conventional (Ordinary) and Structural Equation Modeling (SEM) – Second Generation Statistical methods.