Chapter Four

Result

By structural equation modeling, the researcher can assess how well the scale measures the concept into the estimation of the relationships between dependent and independent variables (Hair, Anderson, Tatham, & Black, 1998). Therefore, this chapter assesses the component structure model of self-concept and self-efficacy and describes the relationship among mathematics self-concept, mathematics self-efficacy, and mathematics achievement in detail.

4.1 Component Structure of Mathematics Self-Concept and Mathematics Self-Efficacy

Upon completion of the pilot study, data from PISA database were input into SPSS11.5. Exploratory Factory Analysis (EFA) was utilized on the data to verify the latent variables and examined its reliability and validity. The purpose of the present study was to summarize the interrelationships among the fourteen items in order to assist in the analysis and conceptualization of the two categories (ie: OECD, 2003). Two factors are self-concept and self-efficacy as shown in Table 3.3-1 and Table 3.3-2.

After EFA, the results of reliability and validity analysis were shown in Table 4.1-1.

(1) Reliability analysis: Five items were used in measuring mathematics self-concept and Cronbach's alpha was .89 which shows the internal consistency.

(2) Validity analysis: After factor analyses, the combination of five items was named as mathematics self-concept. It accounts for cumulative to 69.34 % of the variance which means it has high predictive validity and factorial validity.

Table 4.1-1 Factorial matrix for self-concept items

Variables	Question descriptions	Self-concept	Total variance Explained	Cronbach's Alpha
X_1	I am just not good at mathematics.	**.83**		
X_2	I get good <marks> in mathematics.	**.81**		
X_3	I learn mathematics quickly.	**.79**		
X_4	I have always believed that mathematics is one of my best subjects.	**.77**	**69.34%**	**.89**
X_5	In my mathematics class, I understand even the most difficult work.	**.73**		

For self-efficacy, the results for self-efficacy after EFA were shown in Table 4.1-2.

(1) Reliability analysis: Eight items were used to measure mathematics self-efficacy and Cronbach's alpha was .87 which shows the internal consistency.

(2) Validity analysis: After factor an analysis, the name of mathematics self-efficacy was form by these eight items. It accounts for cumulative to 52.73 % of the variance which means it has high predictive validity and factorial validity.

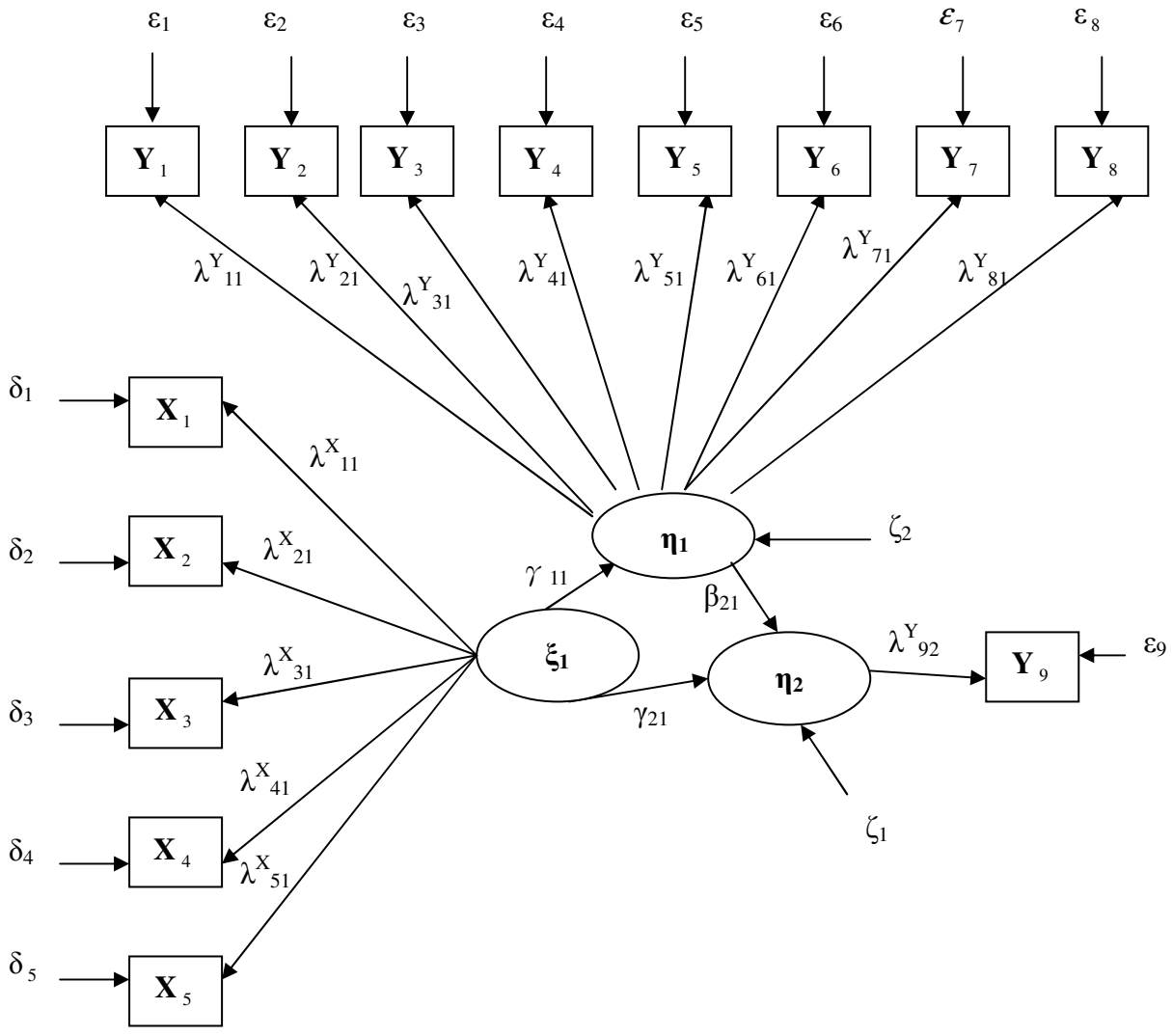
Table 4.1-2 Factorial matrix for self-efficacy items

Variables	Question descriptions	Self-efficacy	Total variance Explained	Cronbach's Alpha
Y_1	Using a <train timetable>, how long it would take to get from Zedville to Zedtown.	**.69**		
Y_2	Calculating how much cheaper a TV would be after a 30 percent discount.	**.72**		
Y_3	Calculating how many square meters of tiles you need to cover a floor.	**.78**	**52.73%**	**.87**
Y_4	Understanding graphs presented in newspaper.	**.61**		
Y_5	Solving an equation like 3x + 5 = 17	**.62**		
Y_6	Finding the actual distance between two places on a map with a 1:10,000 scale	**.72**		
Y_7	Solving an equation like 2(x+3) = (x+3)(x-3)	**.64**		
Y_8	Calculating the petrol consumption rate of a car.	**.63**		

The result of the statistical analysis provided that supported the measurement model. It means that the self-concept and the self-efficacy measurements are acceptable and it can be used to form the structural model of relationship among self-concept, self-efficacy and achievement.

4.2 Relationship Among Self-Concept, Self-Efficacy, and Achievement

Based on the result of good measurement models of self-concept and self-efficacy, the model of relationship among self-concept, self-efficacy and achievement is formed.



ξ_1：Mathematics self-concept η_1：Mathematics self-efficacy η_2：Mathematics Achievement

Figure 4.2-1 The model of relationships among self-concept, self-efficacy and achievement

4.2.1 Correlation Matrix of Measurement Variables

A correlation matrix is calculated among the measured items of self-concept, self-efficacy and achievement. The estimates of the relationships among the variables in the model are calculated using maximum likelihood estimate (MLE). MLE is to estimate the values of the parameters that would result in the highest likelihood of the actual data to the proposed model. Table 4.2.1-1 reports intercorrelations among the 11 variables of self-concept, self-efficacy, and achievement.

Table 4.2.1-1 Zero-Order Correlations Among Measured Items at subject-specific level of Mathematics

	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	X_1	X_2	X_3	X_4	X_5	Y_9
Y_1	1													
Y_2	.52	1												
Y_3	.54	.64	1											
Y_4	.46	.43	.49	1										
Y_5	.37	.50	.45	.33	1									
Y_6	.51	.47	.56	.46	.43	1								
Y_7	.38	.42	.45	.33	.62	.47	1							
Y_8	.48	.39	.48	.42	.29	.51	.42	1						
X_1	.31	.27	.35	.21	.28	.37	.44	.36	1					
X_2	.32	.27	.34	.22	.28	.37	.43	.35	.68	1				
X_3	.33	.28	.36	.27	.30	.35	.41	.37	.60	.61	1			
X_4	.28	.23	.31	.16	.25	.32	.41	.34	.65	.71	.59	1		
X_5	.30	.23	.32	.23	.24	.33	.38	.36	.55	.57	.64	.57	1	
Y_9	.44	.46	.49	.39	.37	.47	.41	.35	.34	.32	.30	.26	.25	1

4.2.2 Parameter Estimation

The estimated parameters are presented in Figure 4.2.2-1 and Table 4.2.2-1 which shows the factor loadings of each indictor are at least above .55 and each indictor can fully explain its psychometric. All standard estimated parameters are between 0 and 1 and this indicates that there is no multicollinearity between each latent variable.

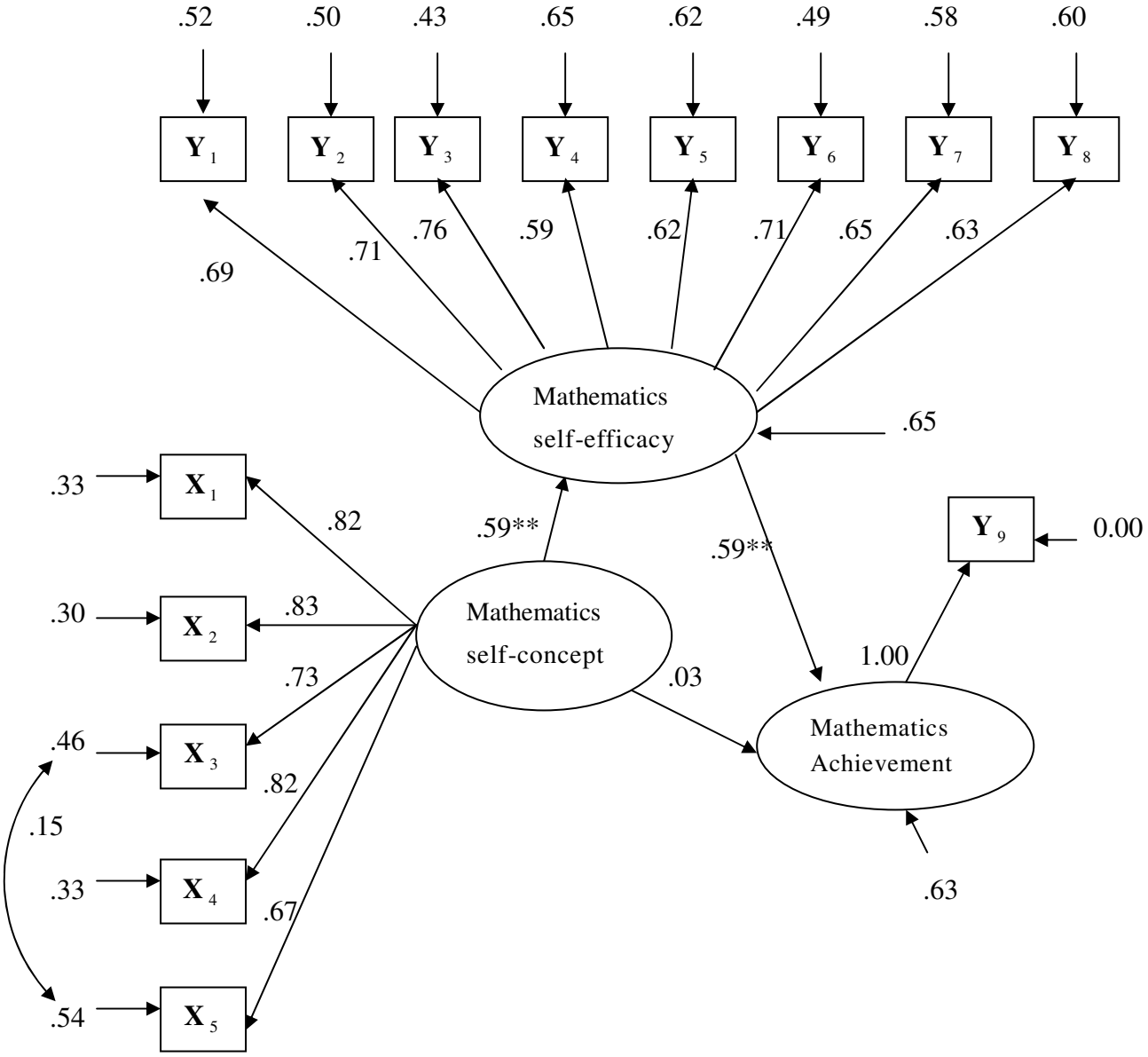


Figure 4.2.2-1 The parameters in the model of relationships among self-concept, self-efficacy and achievement

Note: * $p < .05$

Table 4.2.2-1

Parameter estimation, standard deviation and t-values of ” the model of relationship among self-concept, self-efficacy and achievement”

Parameter	Estimate	Complete Standardized Solution	Standard Error	t-values	Parameter	Estimate	Complete Standardized Solution	Standard Error	t-values
λ^{X}_{11}	.82	.82	.02	45.42	δ_1	.33	.33	.01	24.85
λ^{X}_{21}	.83	.83	.02	46.65	δ_2	.30	.30	.01	23.81
λ^{X}_{31}	.73	.73	.02	38.57	δ_3	.46	.46	.02	28.40
λ^{X}_{41}	.82	.82	.02	45.05	δ_4	.33	.33	.01	25.14
λ^{X}_{51}	.67	.67	.02	34.40	ε_1	.52	.52	.01	29.68
λ^{Y}_{11}	.69	.69	--	--	ε_2	.50	.50	.01	29.11
λ^{Y}_{21}	.71	.71	.02	30.25	ε_3	.43	.43	.01	27.64
λ^{Y}_{31}	.76	.76	.02	32.14	ε_4	.65	.65	.01	31.16
λ^{Y}_{41}	.59	.59	.02	25.47	ε_5	.62	.62	.01	30.79
λ^{Y}_{51}	.62	.62	.02	26.62	ε_6	.49	.49	.01	28.92
λ^{Y}_{61}	.71	.71	.02	30.54	ε_7	.58	.58	.01	30.32
λ^{Y}_{71}	.65	.65	.02	27.89	ε_8	.60	.60	.01	30.58
λ^{Y}_{81}	.63	.63	.02	27.24	ε_9	.00	.00	--	.00
λ^{Y}_{92}	1.00	1.00	--	--	ζ_1	.65	.65	.01	42.79
γ_{11}	.59	.59	.03	23.06	ζ_2	.63	.63	.01	24.03
γ_{21}	.03	.03	.03	1.36					
β_{21}	.59	.59	.02	21.06					

Note: Standard errors and t-values not listed are used as standardized indicators

Modification indices suggested that the freeing the covariance between the error terms for X_3(“I learn mathematics quickly”) and X_5(“ In my mathematics class, I understand even the most difficult work”). According to Piethsch, Walker, and Chapman (2003), it is reasonable to expect the error covariance for them to be correlated because of order effects. The final modified model is shown in Figure 4.2.2-1. The fit of the model was adequate according to each of the fit indices, for example, RMSEA value reduced from .086 to .080. All paths

were significant at an alpha level of significance of .05, except for the path from self-concept to mathematics achievement. The fit of the overall model will be discussed in detail later.

4.2.3 Assessment of Model Fit

Structural Equation Modeling (SEM) is a statistical technique that evaluates the plausibility of a hypothesized model. There are three sections for assessing model fit, including basic model fit, overall model fit, and structure model fit. Table 4.2.3-1 summarized the goodness-of-fit measures for "the model of relationship among self-concept, self-efficacy and achievement". The following sections will explain the model fit in detail.

4.2.3.1 Basic Model Fit of "Relationships among Self-Concept, Self-Efficacy and Achievement"

Before assessing the model fit, it is important to take offending estimates into consideration. Offending estimates refers to improper solutions in structural model or measurement model. When offending estimates exist, it would be wrong even the model has good fit. Yu (2006), Huang (2003), Hair, Anderson, Tatham, and Black(1998) suggest four basic model fit index:

1. There are no negative error variances.
2. Standard coefficients should not exceeding or very close to 1.0.
3. There are no large standard errors associated with any estimated coefficient.

Table4.2.3-1 Summary of Goodness-of-Fit Measures

Test Statistic	Fitness standard value or Critical value	Test Result	Model fit
1. Basic Model Fit Index			
Error Variances	Significant and no negative	All positive and significant	Yes
Standard Coefficients	No exceeding or very close to 1.0	.03 ~ .83	Yes
Standard Error	No large standard error associated with estimated coefficient	.01 ~ .02	Yes
2. Absolute Fit Measures			
χ^2	Non-significant *p*-values indicate a good fit (as small as possible)	χ^2 = 1134.67 *df*= 74 (*p*=0.00)	No
NCP	As small as possible	1067.47	No
GFI	＞0.9; that indicates a good fit	.93	Yes
AGFI	＞0.9; that indicates a good fit	.90	Yes
RMR	＜0.05; smaller residuals indicates a good fit	.051	Yes
SRMR	＜0.05; smaller residuals indicates a good fit	.0051	Yes
RMSEA	＜0.05: close fit < 0.08: reasonable fit ＞0.10: not fit	.080	Yes
ECVI	As small as possible which indicates a good fit	.54	No
3. Incremental Fit Measures			
TLI	＞0.9; that indicates a good fit	.98	Yes

Table4.2.3-1 Summary of Goodness-of-Fit Measures Continued

NFI	＞0.9; that indicates a good fit	.97	Yes
NNFI	＞0.9; that indicates a good fit	.96	Yes
CFI	＞0.9; that indicates a good fit	.97	Yes
IFI	＞0.9; that indicates a good fit	.97	Yes
RFI	＞0.9; that indicates a good fit	.96	Yes
4. Parsimonious Fit Measures			
NC	1＜NC＜3; appropriate model NC＜1; model is overfitted NC＜5; model modification is required	1134.67/74=15.33	No
PGFI	Higher values indicating greater model parsimony	.79	Yes
PNFI	Higher values indicating greater model parsimony	.79	Yes
AIC	Values closer to zero indicate better fit and greater parsimony	210.00	No
CAIC	Values closer to zero indicate better fit and greater parsimony	914.76	No
CN	CN＞200	208.13	Yes
5. Structural Model Fit			
Estimated Parameters	Significant and Symbols are cohered with expected	.03 ~ 1.00	Yes
Correlation coefficients between the latent variables	No exceeding or close to 1.0	.38 ~ .61	Yes
R^2 for structural model	As large as possible	.35and .37	Yes

The model of "Relationships among Self-Concept, Self-Efficacy and Achievement" in the present study fit the four basic fit index according to Figure 4.2.2-1 and Table 4.2.2-1. All error variances (including δ, ε, ζ) are positive and significant (>.05), which fit with the first standard. Standard coefficients of each observed variables and latent variables are between .03 to .83, which fit the second standard. Moreover, the standard errors of estimated coefficient are small (.01 ~ .02) which fit the third standard. Therefore, the present model is in range of acceptable fit.

4.2.3.2 Overall Model Fit of "Relationships among Self-Concept, Self-Efficacy and Achievement"

Before evaluating the structural models, the researcher must assess the overall fit of the model to make sure that it is an adequate proposed model to represent the entire set of causal relationships. It shows how well the parameter estimates account for the observed covariance (Smith & McMillan, 2001). To evaluate the overall model fit, there are numbers of indices, including absolute fit measures, incremental fit measures, and parsimonious fit measures (Yu, 2006, Huang, 2003, Hair, Anderson, Tatham, & Black, 1998):

1. Absolute fit measures: also known as absolute fit measures. It concerned with the ability to reproduce the actual covariance matrix (Kelloway, 1998). It assesses the fit between structural equation model and the data of observed samples.
2. Incremental fit measures: known as comparison to baseline

measures and these are measures of fit relative to the independence model, which assumes that there is no relationship in the data. The independence model is the worst possible model. These measures, with values ranging from 0 to 1, indicate how much better the hypothesized model fits in comparison to the baseline that assumes that there are no relationships in the data (Guarino, 2004).

3. Parsimonious fit measures: it based on the recognition that one can always obtain a better fitting model by estimating more parameters.

Absolute Fit Measures. Three measures of the most basic measures of absolute fit include chi-square, the goodness-of-fit index, and the root mean square residual (Hair, Anderson, Tatham, & Black, 1998). The chi-square value of 1134.67 with 74 degrees of freedom is statistically significant at the .00 significance level. Because of the large sample size (2235 samples in present study), X^2 cannot determine the fitness of the present model. The GFI value of .93 is at a marginal acceptance level, as is the AGFI value of .90. The root mean square error of approximation (RMSEA) has a value of .080, which falls just inside the acceptable range of .08. All of the absolute fit measures indicate that the model is acceptable fit.

Incremental Fit Measures. In addition to the absolute fit measures, a model fit can be evaluated by incremental fit measu ¥s. The values of TLT, NFI, NNFI, CFI, and RFI fall between .96 - .98 which indicate a exact good model fit.

Parsimonious Fit Measures. One applicable measure for evaluating a single model is the normed chi-square measure. With a computed value of 15.33, it falls exceeds the limits of the measures. However, the values of PGFI and PNFI are .66 and .79 which indicate greater model parsimony. CN value is 208.13 (>200) which obtain a better fitting model by estimating more parameters.

As shown in the summary of model fit indices, three types of overall measures of fit indicate a consistent pattern of marginal support for the hypothesized constructs.

4.2.3.3 Structural Model Fit of "Relationships among Self-Concept, Self-Efficacy and Achievement"

Structural model is defined as a set of one or more dependence relationships linking the hypothesized model's construct. The structural model is most useful in representing the interrelationships of variables between dependence relationships (Hair, Anderson, Tatham, & Black, 1998, pp.583). Therefore, it is important to asses the structural model fit. Hair, Anderson, Tatham, and Black (1998) suggest the indices of the structural model as following:

（1） Structural parameters γ and β should be significant and symbols are cohered with expected.

（2） The correlation coefficients of the latent variables should be below .9.

（3） The overall coefficient of determination (R^2) for structural model should be as large as possible.

From Table 4.2.2-1, t-values of $\gamma_{11}$and β_{21} are 23.06 and 21.06, which are significant (>.01), except for γ_{21}. The correlation coefficients of latent variables are between .38 - .61, which are below .9 (Table 4.2.3.3-1). In addition, the overall coefficient of determination (R^2) is calculated and it provides a relative measure of fit for the structural equation (Hair, Anderson, Tatham, & Black, 1998). R^2 value for mathematics self-efficacy is .35 (= 1 - .65). This means that mathematics self-concept can explain 35 percent of the variation in mathematics self-efficacy. Moreover, the combined effect of mathematics self-concept and mathematics self-efficacy achieves an R^2 value of .37 (= 1 - .63); this means that 37 percent of the variance in mathematics achievement is contributed by self-concept and self-efficacy. These results fit the third standard.

To summarize, these fit indexes indicate that the proposed model generally fit the observed data well.

Table 4.2.3.3-1 Correlation Matrix between latent variables

Latent Variable	ξ_1	η_1	η_2
ξ_1 Self-Concept	1.00		
η_1 Self-Efficacy	.61	1.00	
η_2 Math Achievement	.59	.38	1.00

4.2.4 Effect between Latent Variables

Of all path coefficients from the independent variables to performance, those from mathematics self-efficacy ($\beta = .59, t = 23.06$) and mathematics self-concept ($\beta = .03, t = 1.35$) were significant. Table 4.2.4-1 provides an overview of direct and indirect effects of mathematics self-efficacy on mathematics self-concept and mathematics performance respectively. The total effects of mathematics self-concept on mathematics self-efficacy and mathematics achievement are .59 and .3768 (.59 x .59 + .03= .3781). This effect indicates that mathematics self-efficacy strongly influences on mathematics achievement. Mathematics self-concept has a direct effect on mathematics self-efficacy that shows the causal relationship between the two. Mathematics self-concept has direct and indirect effects on mathematics achievement which are .03 and .3481 (= .59 x .59). Although the value is very small, it is significant. This result means that mathematics self-concept can not only directly predict mathematics achievement but also can indirectly predict mathematics achievement through the mediating effect of mathematics self-efficacy.

The structural model was developed to examine the relationships of the two self-perceptions in the domain of mathematics performance. The paths from the self-perception variables to the performance were significant, which suggested that the two constructs were related to performance in mathematics but the ways are different. Mathematics self-efficacy can have great impact on mathematics performance and the indirect effect of mathematics self-concept on mathematics performance

is stronger than the direct effect of its on performance.

Table 4.2.4-1 Effect between latent variables

	ξ_1 Self-Concept		
	Direct Effect	Indirect Effect	Total Effect
η_1 Self-Efficacy	.59	---	.59
η_2Math achievement	.03	.3481	.3781

4.2.5 Testing Mediation

The effect between mathematics self-concept and mathematics achievement, as presented in Table 4.2.4-1, the direct effect between these two was not significant. But it was significant through the indirect effect of mathematics self-efficacy on mathematics performance. Therefore, it is necessary to examine the possibility of the existing mediator.

According to Baron & Kenny (1986), a variable is needed to meet the following conditions in order to functions as a mediator (shown in üïgure 4.2.5-1): (a) variations in levels of the independent variable significantly account for variations in the presumed mediator (ie. Path *a*), (b) variations in the mediator significantly account for variations in the dependent variable (ie. Path *b*) and (c) when Paths *a* and *b* are controlled, a previously significant relation between the independent and dependent variables is no longer significant, with the strongest demonstration of mediation occurring when Path *c* is zero (p. 1176).

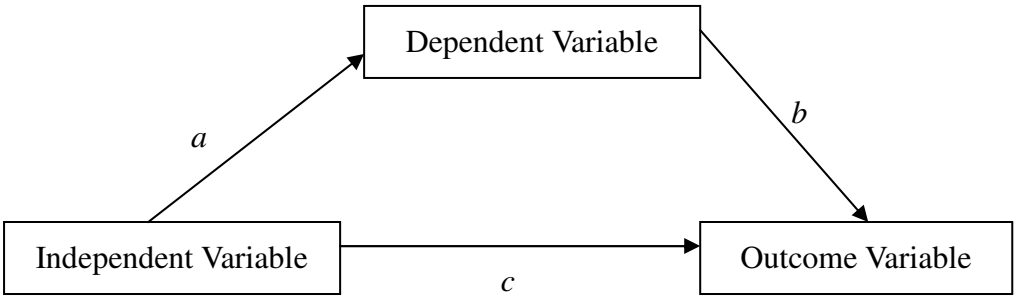


Figure 4.2.5-1 Mediational model

Note. From "The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations" by Baron R. M. & Kenny D. A., 1986, *Journal of personality and social psychology, 51*(6), p. 1176.

In order to test mediation, Baron and Kenny (1986) suggested that one should estimate the three regression equations: (a) regressing the mediator on the independent variable, (b) regressing the dependent variable on the independent variable, (c) regressing the dependent variable on both the independent variable and on the mediator (p. 1177). SEM was used to testing mediation and the processes were shown below:

1. To examine whether self-concept (independent variable) affects self-efficacy (mediator) or not.
2. To examine whether self-concept (independent variable) affect mathematics achievement (dependent variable) or not.
3. To examine whether self-efficacy (mediator) affect mathematics achievement (dependent variable) or not.

As shown in Table 4.2.5-1, the effect of self-concept to self-efficacy

is .60, and the effect of self-concept to mathematics achievement is .38 which fit the regression equations 1 and 2 (Baron & Kenny, 1986). Moreover, the effect of self-efficacy to achievement is .61 which is significant. Comparing with Figure 4.2.2-1, when Paths *a* and *b* are controlled, a previously significant relation between the self-concept and mathematics achievement is no longer significant (γ_{21} decreased from .38 to .03). This result is consistent with standards that Baron and Kenny (1986) suggested. All conditions hold in the predicted direction, self-efficacy can be seen as a mediator.

Table 4.2.5-1 Regression equations for mediational model

Paths	Standardized Solution	Standard Error	*t*-value
Path *a*	.60	.02	25.47
γ_{11} : self-concept (ξ_1)→ self efficacy (η_1)			
Path *b*	.61	.02	30.74
β_{21} : self-efficacy(η_1)→achievement (η_2)			
Path *c*	.38	.02	18.22
γ_{21} :self-concept(ξ_1)→achievement (η_2)			

4.2.6 Cross-Validation

In order to provide a second confirmation of the present measurement theory, cross-validation was used. The sample was randomly split into two groups so each sample meets the minimum size requirement (Yu, 2006). Group 1 was used to test minor refinement such as freeing the covariance between the error terms. Group 2 was used to cross-validate the original model. Group 1 includes 2235 students (1181 girls) and Group 2 includes 2169 students (1011 girls).

According to Hair, Anderson, Tatham and Black (2006), CFI is useful in establishing the cross-validation (p. 821), since the sample size issues for chi-square. Moreover, for the CVI value, it should be as small as possible when comparing with the original model as Browne and Cudeck (1989) suggested. As shown in Table 4.2.6-1, CFI value is .95, which fit the index before modification of the model. The CVI value is 1.22. After modification, CFI value is .96 which is bigger than .90, which also fits the index. The CVI value is 1.16, which is smaller than original model. The two sets of samples have presented cross validity, the modified model are highly acceptable. Such verification may be capitalizing on chance and conceptual relationships unique to the population of students participating in the present study. However, this evidence supports the validity of the modified proposed measurement models. Thus, it is necessary to cross-validate these results with independent samples to determine whether such modifications lead to replicable results with a range of different participants.

Table 4.2.6-1 Fit indice for cross-validation

Test Statistic	Fitness standard value or Critical value	Test Result	Model fit
Original model			
CVI	As small as possible	1.22	YES
CFI	＞0.9; that indicates a good fit	.95	YES
Modified model			
CVI	As small as possible	1.16	YES
CFI	＞0.9; that indicates a good fit	.96	YES