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Structural Equation Modelling (SEM) of Risk Factors for Mathematical Anxiety in Tertiary Students

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ABSTRACT

Mathematics anxiety or mathematics phobia is a general term for several disorders that will cause panic attacks, nervousness, and social anxiety, which potentially gave negative outcomes when faced with any situation related to mathematical problems. Therefore, the purpose of this study is to examine the factors that influence mathematics anxiety among private college students. Two private colleges from north Malaysia were selected from its nine branches all over Malaysia. These colleges offered 9 different courses where each course offered mathematics subject. After conducting factor analysis, five factors were identified as reasons for the occurrence of mathematics anxiety among students. The factors are student attitude, role of teacher, skills, emotions, and peers. Structural equation model has shown that there are relationships between these five factors. Peers and role of teachers proven to have a positive direct effect on mathematics anxiety with role of teachers was found to be the strongest factor. Meanwhile, students' attitude and skills have a negative direct effect on mathematics anxiety. Finally, emotions influence mathematics anxiety indirectly through students' attitude.

Keywords: Mathematical Anxiety, Structural Equation Modelling, Factor Analysis.

1. INTRODUCTION

Richardson and Suinn (1972) defined math anxiety as a tense feeling that may hamper the ability to use numbers to solve mathematical operations, both in daily life as well as in academic. People with mathematics anxiety generally would avoid learning mathematics (Hembree, 1990; Ashcraft and Krause, 2007). By having this type of anxiety, one can easily forget mathematical equations and lose confidence in their mathematical ability (Zakaria, Zain, Ahmad, and Erlina (2012). This hindrance will cause a decline in grades performance among learners (Ashcraft and Kirk, 2001; Gunderson, Park, Maloney, Beilock and Levine, 2018), reduce interest in other STEM subjects (Moakler, and Kim, 2014; Beilock and Maloney, 2015; Drew, 2015), promote the lack of quantitative literacy (Henrich, and Lee, 2011; Slootmaeckers, Kerremans and Adriaensen, 2014), and further affect their analytical ability in making informed decision making in the future (Krinzinger, Kaufmann, and Willmes, 2009; Warwick, and Howard, 2016; Wedage, 2016). Wondimu et al. (2012) believed that by treating mathematics anxiety, students would be able to keep their emotion in control, resulting to better handle their anxiety.

In Malaysia, similar concerns are shared in the academic community. Puteh and Khalin (2016) and Zakaria and Nordin (2008) found a negative correlation between mathematics anxiety and students' performance in Malaysia secondary schools and matriculation students. In higher learning setting, several studies on this correlation have been conducted by Vitasari, Wahab, Othman, Herawan and Sinnadurai (2010), Wahid, Yusof and Razak (2014), and Sahri, Kamaruzaman, Jamil and Shaharanee (2017), to name only a few.

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The factors that may influence learning mathematics have also actively investigated. An investigation to students in Business Mathematics program, UiTM Merbok, Kedah found that attitude, role of teachers, peers and interest are the factors that influence student performance (Mokhtar, Md Yusof and Misiran, 2012). In a separate study, Usop et al. (2009) found that teachers are the most influential factor that contributes to mathematics anxiety. Besides, emotion towards learning mathematics (Frenzel, Pekrun and Goetz, 2007) and mathematical skills (Danielle, 2006) are among the contributing factors towards mathematics anxiety among students of different level. This study aims to identify the possible causal factors that lead to mathematics anxiety among tertiary students of private colleges in Malaysia (throughout this manuscript, the two colleges will be addressed as College S and College Z).

2. METHODOLOGY

2.1 Sample of Data

In this study, diploma students in College S and College Z were selected. One hundred and seventy-five students (77 male and 98 female) undertaking mathematics courses from January 2018 to May 2018 from six programs were selected by using a stratified random sampling method. The entire respondents were randomly selected with no preference in age or gender. The selected programs were Diploma in Accountancy, Diploma in Business Management, Diploma in Computer System and Networking, Diploma in Information Technology, Diploma in Multimedia, and Diploma in Multimedia with Management.

2.2 Data Collection

Data collection method and the developed questionnaires are based on previous literature. The semantic scale was used, with items' scale ranges from 1 (strongly disagree) to 5 (strongly agree). The questionnaire contains demographic items, i.e. gender, current academic programs, and posed questions related to mathematics anxiety. A pilot test was conducted to 19 students to test the reliability and validity of the questionnaires. The measured Cronbach's alpha for all items is 0.855, which indicated that the items have relatively high internal consistency, suggesting that the questionnaire has very good reliability. Note that the reliability coefficient of 0.70 or higher is sufficient to be considered acceptable (Venkatesan, 2009). This survey was conducted at the beginning of class. The result of the internal consistency of reliability for all items is shown in Table 1.

Table 1 Reliability Statistics

Cronbach's Alpha	*N* of Items
.855	32

2.3 Data Analysis

2.3.1 Factor Analysis and Structural Equation Modelling (SEM)

There are thirty-two items related to mathematics anxiety among College S and College Z students. To determine whether there is a major cause for this mathematics anxiety, factor analysis has been conducted. Next, the structural equation model is used to construct the relationship between factors providing consistency and comprehensive explanation of the actual phenomena. The original model from previous literature is used as a reference to develop the new model based on the factors obtained in this study. The validity of the model is based on the good fit value of chi-square.

3. ANALYSIS AND RESULTS

3.1 Factor Analysis

3.1.1 Kaiser-Meyer-Olkin (KMO) and Bartlett's Test

Based on Bartlett's test of sphericity, the result shows factor analysis is suitable for this study (Chi-Square = 2337.635, Df = 496, sig < 0.001). This result indicates that the correlation matrix is not an identity matrix, thus factor analysis was appropriate. The value of KMO is at 0.823 with acceptable adequacy. To assess the adequacy of sampling and evaluating the correlation and partial correlation data to determine whether factors tend to consolidate statistics KMO, the value must be greater than 0.600 (Venkatesan, 2009). Then, principal components methods of extraction and varimax rotation are used to estimate the starting factor for these items.

Table 2 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.823
Bartlett's Test of Sphericity	Approx. Chi-Square	2337.635
	Df	496
	Sig.	.000

3.1.2 Scree Plot

Factor analysis is needed to reduce the number of variables to smaller ones called factors to give a superior comprehension of the information. The graphical scree plot can determine the number of factor or components to be maintained. Based on the scree plot in Figure 1, five factors need to be extracted.

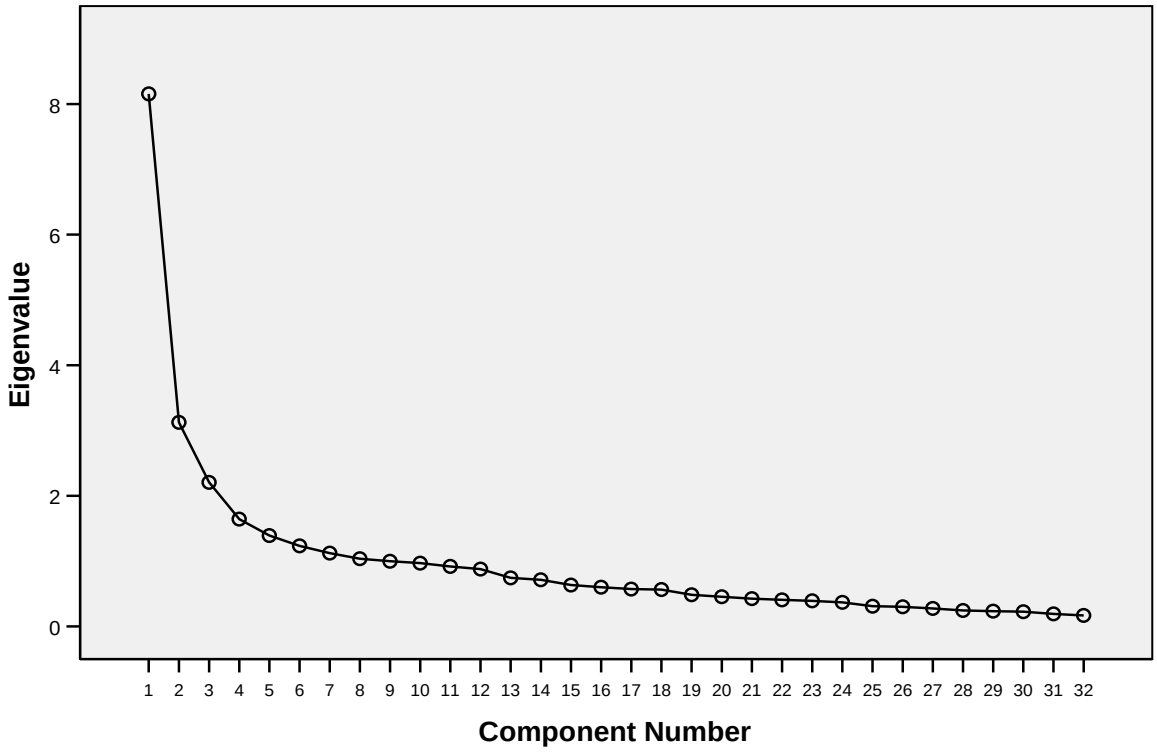

Figure 1. Scree Plot Diagram Showing the Eigenvalues of the Items.

Table 3 shows items being classified into five factors. Factor 1 = Students attitude, Factor 2 = Role of Teacher, Factor 3 = Skills, Factor 4 = Emotions, and Factor 5 = Peers. The items 27, 5, 2, 9, 20, 1 and 4 were loaded under Factor 1. Items 18, 22, 14, 26, 17, 3, 32, 21, 15 and 6 were loaded under Factor 2 with '*Lecturers encourage students to meet and ask questions if there are problems in Mathematics*' is the highest loaded item. Items 28, 31, 24, 29, 25 and 11 were loaded under Factor 3 with '*Mathematics is useful in all fields of work*' is the highest loaded item. Items 8, 16, 12, 19 and 23 were loaded under Factor 4 with '*Mathematics too many numbers and words caused me to become confused*' is the highest loaded item. Lastly, items 13, 30, 7 and 10 were loaded under Factor 5 with '*I am easily influenced by the invitation of their peers in learning mathematics*' is the highest loaded item.

Table 3 Categories of Factors That Influence Mathematics Anxiety

Item No.	
	Factor 1: Students' Attitude
27	I always do mathematics exercise when I have free time.
5	I enjoy reading and referring books in Mathematics.
2	I always help other partners to resolve the problems of Mathematics.
9	Mathematics can help me in learning other subjects.
20	I always memorize mathematical formulas.
1	I prefer mathematics than other subjects.
4	Normally, I like to solve mathematics problems.
	Factor 2: Role of Teacher
18	Lecturers encourage students to meet and ask questions if there are problems in Mathematics.
22	Lecturers always make thorough preparation in teaching.
14	Lecturers are always ready to discuss with students about topics that are poorly understood.
26	Lecturers are always an encouragement to students to learn mathematics seriously.
17	I often discuss with friends about the problems of Mathematics.
3	Lecturer success to attracted and gives attention to students while teaching.
32	Lecturers can answer all questions submitted by students of Mathematics.
21	The successes of their peers in mathematics give a boost to me to be more work.
15	Mathematics is useful in the today and future life.
6	Mathematics can help to strengthen my mind.
	Factor 3: Skills
28	Mathematics is useful in all fields of work.
31	Math skills enable a person going into a work of professional and technical fields.
24	With a Master of Mathematics, my job opportunities in the future better.
29	My friends always help me solve mathematics problems.
25	I need knowledge of mathematics to solve problems in my daily work.
11	My friends always engaged me with mathematics problem-solving.
	Factor 4: Emotions
8	Mathematics too many numbers and words caused me to become confused.
16	Mathematics allows me to think logically and reasonably.
12	I always passed the Mathematics test.
19	Although the study of mathematics requires hard work, I feel good.
23	Mathematics test question is more difficult when compared with other subjects of test questions.
	Factor 5: Peers
13	I am easily influenced by the invitation of their peers in learning mathematics.
30	Sometimes lecturers are not confident in teaching.
7	Friends and I form discussion groups to work together to learn mathematics.
10	I always imitate my friend answer in mathematics.

3.2 Structural Equation Modelling (SEM)

Further, Structural Equation Modelling (SEM) is performed to test the fit relationships among multiple variables in mathematics anxiety. The AMOS 21 software was used, and the estimation procedure produced the maximum likelihood estimation. The dimensions of mathematics anxiety model are shown in Table 4 below.

Table 4 Dimensions of Mathematics Anxiety Model

Measured Variables	Mathematics Anxiety (Dependent Variable)
V33	I am feeling angry when answering questions in Mathematics.
V34	I feel confident to answer questions in Mathematics.
V35	I love Mathematics.
	Factor 1: Students' Attitude (First Independent Variable)
V27	I always do mathematics exercise when I have free time.
V5	I enjoy reading and referring books in Mathematics.
V2	I always help other partners to resolve the problems of Mathematics.
V9	Mathematics can help me in learning other subjects.
V20	I always memorize mathematical formulas.
V1	I prefer mathematics than other subjects.
V4	Normally, I like to solve mathematics problems.
V6	Mathematics can help to strengthen my mind.
V12	I always passed the Mathematics test.
V19	Although the study of mathematics requires hard work, I feel good.
	Factor 2: Role of Teachers (Second Independent Variable)
V18	Lecturers encourage students to meet and ask questions if there are problems in Mathematics.
V22	Lecturers always make thorough preparation in teaching.
V14	Lecturers are always ready to discuss with students about topics that are poorly understood.
V26	Lecturers are always an encouragement to students to learn mathematics seriously.
V17	I often discuss with friends about the problems of Mathematics.
V3	Lecturer successes to attracted and give attention to students while teaching.
V32	Lecturers can answer all questions submitted by students of Mathematics.
V21	The successes of their peers in mathematics give a boost to me to be more work.
V15	Mathematics is useful in the today and future life.
	Factor 3: Skills (Third Independent Variable)
V28	Mathematics is useful in all fields of work.
V31	Math skills enable a person going into a work of professional and technical fields.
V24	With a Master of Mathematics, my job opportunities in the future better.
V29	My friends always help me solve mathematics problems.
V25	I need knowledge of mathematics to solve problems in my daily work.
V11	My friends always engaged me with mathematics problem-solving.
	Factor 4: Emotions (Fourth Independent Variable)
V8	Mathematics too many numbers and words caused me to become confused.
V16	Mathematics allows me to think logically and reasonably.
V23	Mathematics test question is more difficult when compared with other subjects of test questions.
	Factor 5: Peers (Fifth Independent Variable)
V13	I am easily influenced by the invitation of their peers in learning mathematics.
V30	Sometimes lecturers are not confident in teaching.
V7	Friends and I form discussion groups to work together to learn mathematics.
V10	I always imitate my friend answer in mathematics.

3.2.1 Goodness of Fit for Individual Constructs

In performing the procedure of structured equation model, several criteria have to be fulfilled. Three criteria need to be fulfilled to make sure the model of structured equation model is fit, which are absolute model fit, incremental fit and parsimonious fit. At least one of the indexes need to be fulfilled for each criterion. The criteria for model fit assessment for structured equation model as in Table 5.

Table 5 Criteria for Model Fit Assessment

Name of Index	Characteristics	Comments	Literature Support
Absolute Model Fit: the degree to which the proposed model predicts the observed covariance matrix			
Root Mean Square Error of Approximation (RMSEA)	Average discrepancy per *df* expected to occur in the population	< 0.05 (good) < 0.08 (acceptable) < 0.10 (mediocre)	Browne and Cudeck (1993), MacCallum et al. (1996)
Goodness-of-Fit Index (GFI)	Overall degree of fit	> 0.9 is a good fit	Browne and Cudeck (1989)
Incremental Fit: compares the proposed model to a realistic null or baseline model			
Comparative Fit Index (CFI)		> 0.9 is a good fit	Bentler (1990)
Tucker-Lewis Index (TLI)	Comparative index between the proposed and null model	> 0.9 is a good fit	Bentler and Bonett (1980)
Normed Fit Index (NFI)	Relative comparison of the proposed model to the null model	> 0.9 is a good fit	Bentler and Bonett (1980)
Parsimonious Fit: diagnostic on model fit due to overfitting data with too many coefficients			
Normed Chi-Square (CMIN/DF)	X^2/df	The value should be less than 5.0	Marsh and Hocevar (1985)

Table 6 illustrated the results for students' attitude, role of teachers and skills that are fit, consistent with all values of CMIN/DF, GFI, AGFI, CFI, CRATIO and RMSEA, all within acceptable values. Meanwhile, emotions and peers are not fit since the chi-square and the associated degrees of freedom is more than 3.0, with the value of RMSE higher than 0.08.

Table 6 Goodness of Fit

	Students' Attitude	Role of Teachers	Skills	Emotions	Peers
CMIN/DF	2.340	2.070	1.551	20.259	4.462
GFI	0.057	0.939	0.044	0.071	0.900
AGFI	0.854	0.898	0.974	0.954	0.905
CFI	0.932	0.922	0.978	0.910	0.631
CRATIO	0.778	0.750	0.600	0.500	0.667
RMSEA	0.088	0.780	0.056	0.134	0.141

3.2.2 Hypothesized Model

Measured variables are represented by a box with labels corresponding to the mathematics anxiety questionnaire. Each measured variable has an error term represented by circles. Latent constructs are represented by oval shape. Six latent variables are assumed with six confirmatory factor analyses used to derive them. Single-headed arrows indicate causal effects from a construct to a measured variable.

Based on Figure 2, the hypotheses are listed as the following:

H_1 : The is a significant and direct influence of student's attitude towards mathematics anxiety
H_2 : There is a significant and direct influence of role of teachers and mathematics anxiety
H_3 : There is a significant and direct influence of skills and mathematics anxiety
H_4 : There is a significant and direct influence of emotions and mathematics anxiety
H_5 : There is a significant and direct influence of peers and mathematics anxiety

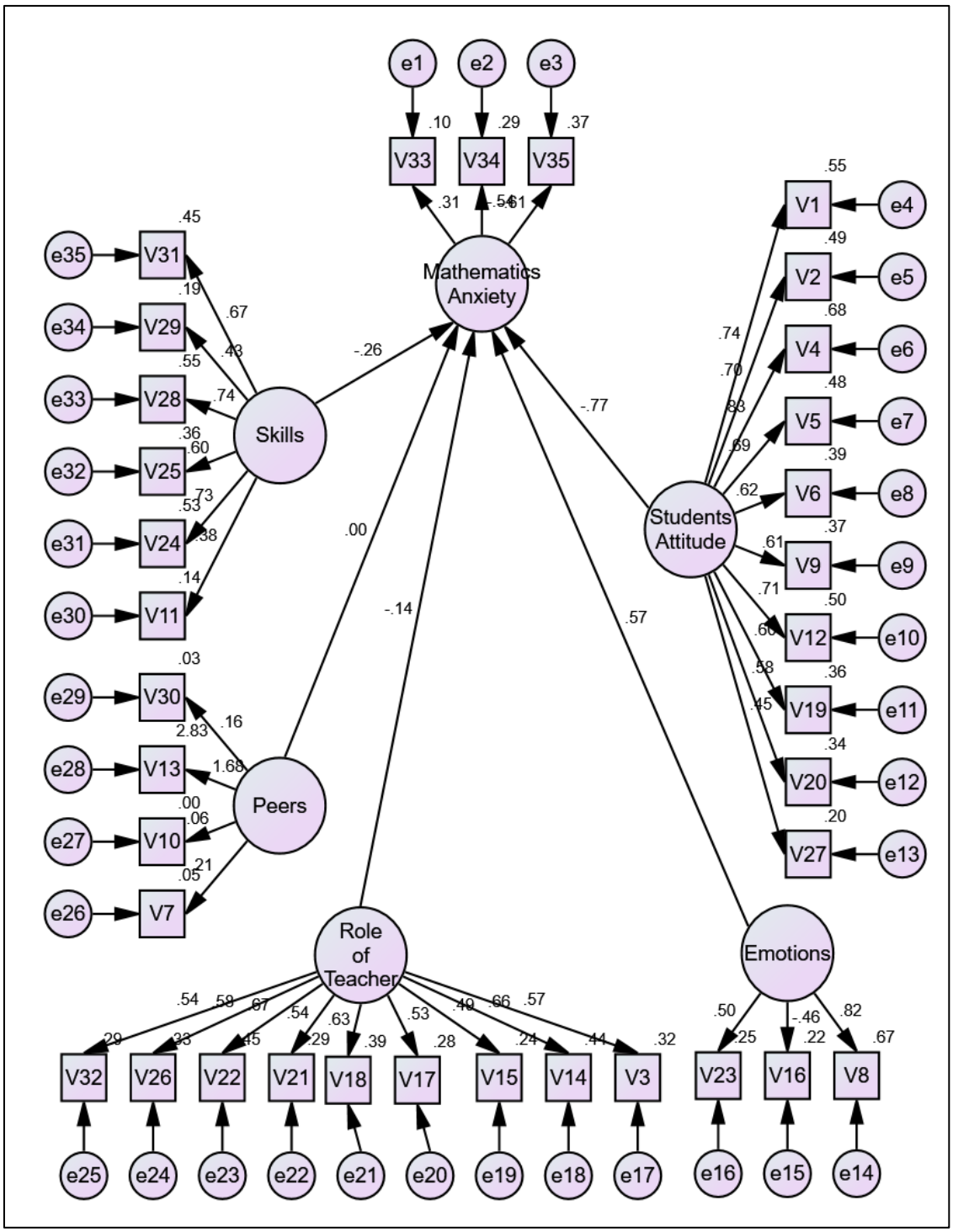

Figure 2 Hypothesized Measurement Model

Then, the goodness-of-fit test statistics were investigated. The value of Chi-square and the associated degrees of freedom shows a good fit. However, all the values of CMIN/DF, GFI, AGFI, CFI, CRATIO and RMSEA do not fulfil the acceptable values, which indicate it is not a good fit model. Additionally, based on Table 7, there are only two parameters (Students Attitude and Emotions) estimates are significantly different from 0 while the rest do not give significant results. Therefore, the measurement model is not valid and need to refine the measures and design a new study. Besides, the standardized regression estimates are comparable, which may assist in the selection of more important factors and relationships.

Table 7 Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Mathematics_Anxiety	<---	Students_Attitude	-.348	.094	-3.711	***	
Mathematics_Anxiety	<---	Skills	-.246	.114	-2.163	.031	
Mathematics_Anxiety	<---	Role_of_Teacher	-.094	.065	-1.447	.148	
Mathematics_Anxiety	<---	Peers	-.005	.082	-.056	.955	
Mathematics_Anxiety	<---	Emotions	.202	.064	3.175	.001	

Table 8 Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Mathematics_Anxiety	<---	Students_Attitude	-.767
Mathematics_Anxiety	<---	Skills	-.258
Mathematics_Anxiety	<---	Role_of_Teacher	-.136
Mathematics_Anxiety	<---	Peers	-.002
Mathematics_Anxiety	<---	Emotions	.571

3.3 New Model

Two constructs or more were combined in order to obtain a fit model. Then, the goodness of fit test statistics has been checked until all the acceptable value of indices are fulfilled. There are a few ways that can be used to get a fit model such as remove the items, add another path and two-headed arrows between the constructs. Items with low loadings become candidates for deletion. From the findings below, it can be seen that all the combinations and the final model are well fit.

3.3.1. Mathematics Anxieties and Students' Attitude

To assess the fit of the model for both students' attitude factors and mathematics anxiety, numbers of descriptive fit indices were computed such as: χ^2/df = 1.866, RMR = 0.043, GFI = 0.930, AGFI = 0.910, NFI = 0.900, RFI = 0.953, TLI = 0.960, CFI = 0.970, PNFI = 0.830, and RMSEA = 0.040. The results show that the model fit the data of students' attitude factors and mathematics anxiety.

3.3.2. Mathematics Anxieties, Students' Attitude and Role of Teachers

The analysis relied on a number of goodness of fit test as the following. The results of χ^2/df = 2.440, RMR = 0.042, GFI = 0.905, AGFI = 0.900, NFI = 0.908, RFI = 0.928, TLI = 0.909, CFI = 0.937, PNFI = 0.868, and RMSEA = 0.076 show the model is fit for both factors are students' attitude and role of teachers, and mathematics anxiety.

3.3.3. Mathematics Anxiety, Students' Attitude, Role of Teachers and Skills

The model of combinations from these four constructs also shows it is a good fit model since the values of χ^2/df = 2.535, RMR = 0.048, GFI = 0.980, AGFI = 0.930, NFI = 0.970, RFI = 0.965, TLI = 0.960, CFI = 0.980, PNFI = 0.827, and RMSEA = 0.070 fulfil all the acceptable values.

3.3.4. Mathematics Anxiety, Students' Attitude, Role of Teachers, Skills and Emotions

Based on Table 9 and Table 10, the results show it is a good fit model according to the values of χ^2/df = 2.956, RMR = 0.07, GFI = 0.980, AGFI = 0.899, NFI = 1.000, RFI = 1.000, TLI = 1.000, CFI = 1.000, PNFI = 0.858, and RMSEA = 0.030.

Table 9 Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P
Students_Attitude	<---	Emotions	-.886	.128	-6.923	***
Students_Attitude	<---	Role_of_Teachers	1.028	.269	3.819	***
Mathematics_Anxiety	<---	Students_Attitude	-.647	.145	-4.476	***
Mathematics_Anxiety	<---	Peers	.068	.136	.500	.617
Mathematics_Anxiety	<---	Role_of_Teachers	.397	.168	2.356	.018
Mathematics_Anxiety	<---	Skills	-.095	.126	-.751	.453

Table 10 Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Students_Attitude	<---	Emotions	-.815
Students_Attitude	<---	Role_of_Teachers	.485
Mathematics_Anxiety	<---	Students_Attitude	-1.131
Mathematics_Anxiety	<---	Peers	.081
Mathematics_Anxiety	<---	Role_of_Teachers	.328
Mathematics_Anxiety	<---	Skills	-.116

3.5 Final Model

Combining all the constructs has developed the final model or structural model. AMOS suggests the correlation structures between the constructs after the fitting of the initial model without any correlated constructs. This helps improve the overall model fitting. Then, the validity of the structural model is assessed based on the goodness of fit test. The results show that the model fit well (χ^2/df = 1.995, RMR = 0.051, GFI = 0.905, AGFI = 0.863, TLI = 0.921, CFI = 0.935, PNFI = 0.820, and RMSEA = 0.076).

3.6 Findings

Based on Figure 3, peers and role of teachers have a positive direct effect on mathematics anxiety. Meanwhile, students' attitude and skills have a negative direct effect on Mathematics Anxiety. There was no direct effect of emotions on mathematics anxiety but there is an indirect effect through students' attitude. Such finding can be interpreted as emotions negatively affected mathematics anxiety through their negative students' attitude. The role of teachers also has an indirect effect through students' attitude.

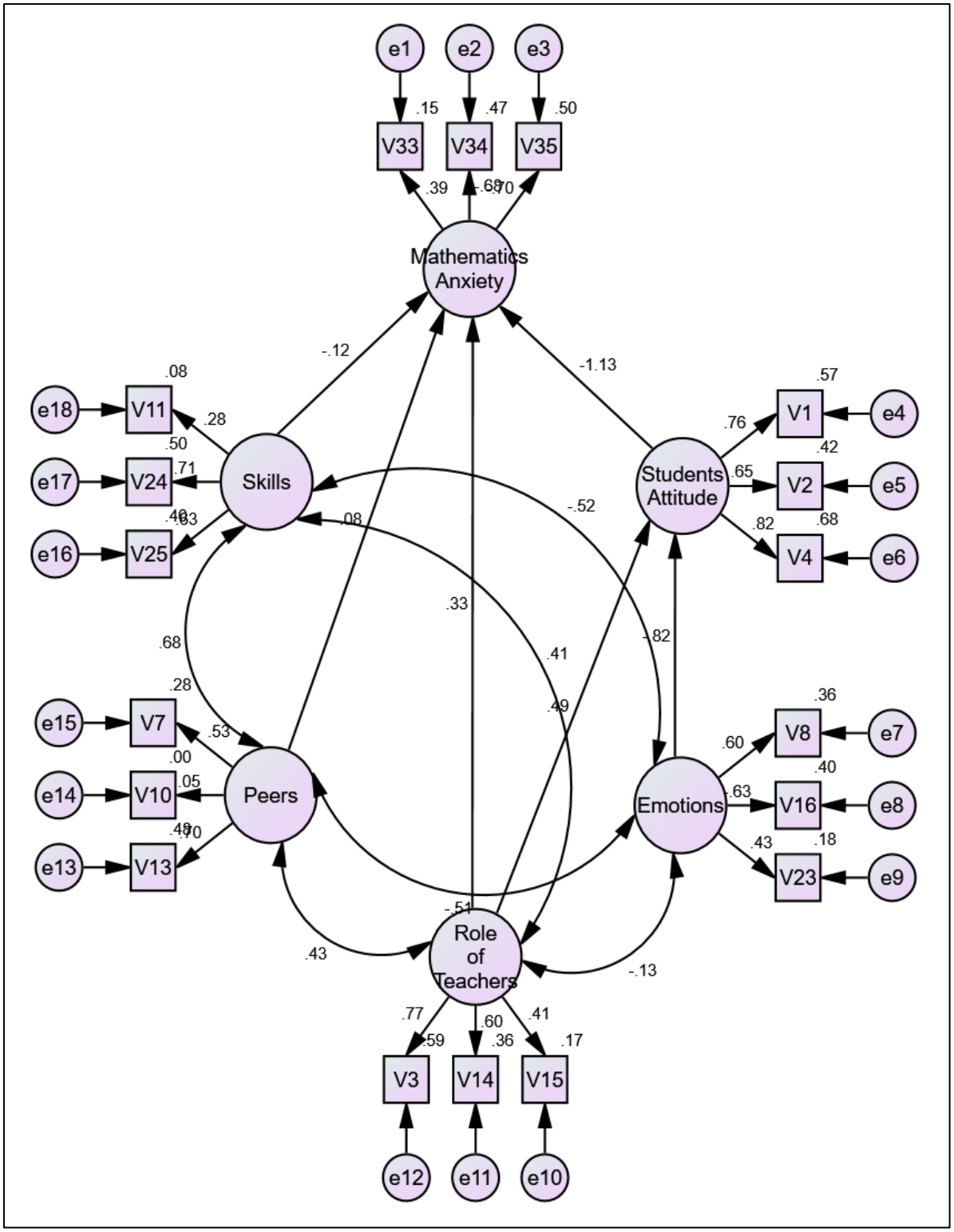

Figure 3. Structural Equation Model.

4. CONCLUSION AND DISCUSSION

In this study, the factors that contributed to mathematics anxiety among student in College S and College Z were investigated. Five factors, i.e. student's attitude, role of teachers, skills, emotion, and peers were identified. In Factor 1 (students' attitude), most students strongly agreed with

this factor. They enjoy doing mathematics exercise during leisure time, referring to mathematics book and always memorizing formulas. They also help other students to resolve mathematical problems.

In Factor 2 (role of teacher), results showed a strong positive response from students. It can be assumed that students enjoyed and contented with the current teaching method. They enjoyed encouragement from lecturers and discussion when solving mathematics problems. In Factor 3 (skills), students knew that mathematics knowledge is useful in various works. Skills in mathematics also enable one to have a better job opportunity, in particular the professional and technical work. Knowledge of mathematics can also help solve daily work problems.

In Factor 4 (emotion), students do not agree that they are confused with mathematics problems that have too many numbers and words. Mathematics test question is not difficult when compared with other subjects. Mathematics allows them to think logically and reasonably although the study of mathematics requires hard work. In Factor 5 (peers), students prefer to work with a friend or in a group to solve mathematics problems. Such practice is helpful while dealing with doubt during class. It can also increase their confidence level in solving mathematical problems.

In summary, the structural equation modelling adopted in this study found that all factors are significant determinants of mathematics anxiety. All the hypotheses proposed in this study were supported. It is beneficial if College S and College Z can construct related programs for student to reduce mathematics anxiety to ensure better performance in the future.

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