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Structural Equation Modeling (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 facing with any situation that related with 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 in all over Malaysia. These colleges offered 9 difference courses which each courses offered Mathematics subject. After conducting a factor analysis, five factors were identified as reasons to 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. While, students' attitude and skills had negative direct effect on mathematics anxiety. Finally, emotions influence mathematics anxiety indirectly through students' attitude.

Keywords: mathematical anxiety, structural equation modeling, factor analysis

1. INTRODUCTION

Richardson and Suinn (1972) defined math anxiety as a tense feeling that may hampers 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 & Krause, 2007). By having this type of anxiety, one can easily forget mathematical equations and lose confidence in their mathematical ability (Zakaria, Zain, Ahmad, & Erlina (2012).

This hindrance will cause a decline in grades performance among learners (Ashcraft & Kirk, 2001; Gunderson, Park, Maloney, Beilock & Levine, 2018), reduce interest in other STEM subjects (Moakler, & Kim, 2014; Beilock & Maloney, 2015; Drew, 2015), promote the lack of quantitative literacy (Henrich, & Lee, 2011; Slootmaeckers, Kerremans & Adriaensen, 2014), and further affect their analytical ability in making informed decision making in the future (Krinzinger, Kaufmann, & Willmes, 2009; Warwick, & 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 academic community. Puteh and Khalin (2016) and Zakaria & Nordin (2008) found negative correlation between mathematics anxiety and students performance in Malaysia secondary schools and matriculation students. In higher learning setting, several studies on this correlation has also been conducted by Vitasari, Wahab, Othman, Herawan & Sinnadurai (2010), Wahid, Yusof & Razak (2014), and Sahri, Kamaruzaman, Jamil & Shaharanee, (2017), to name only a few.

The factors that may influenced 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 influencing student performance (Mokhtar, Md Yusof amd Misiran, 2012). In 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 also among the contributing factors towards mathematics anxiety among students of different level. In this study, we aims to identify the possible causal factors that lead to mathematics anxiety among tertiary students of private colleges in Malaysia (throughout this manuscript, 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 in January 2018 to May 2018 from six programs were selected by using 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 including the developed questionnaires are based on previous literature. 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 reliability coefficient of 0.70 or higher is sufficient to be considered acceptable (Venkatesan, 2009). This survey was conducted in 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 Modeling (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, 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 guide 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 the 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.

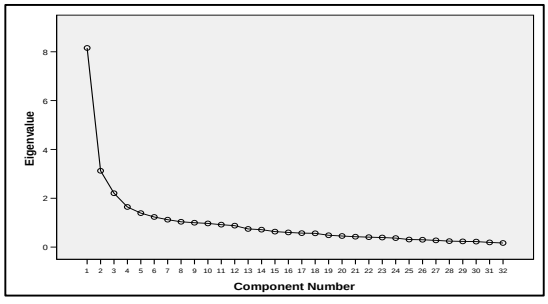

Figure 1: Scree Plot Diagram Showing the Eigenvalues of the Items

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 a 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 a 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 a 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 a 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 the 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 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 but 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 Modeling (SEM)

Further, 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 but 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 the 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 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. There are three criteria that need to be fulfilled in order 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 index that need to be fulfill 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 over fitting 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 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 representing as a box with labels corresponding to the mathematics anxiety questionnaire. Each measured variable has an error term that represented in the circles. Latent constructs are an oval. 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 the Figure 2, the hypotheses are listed below:

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

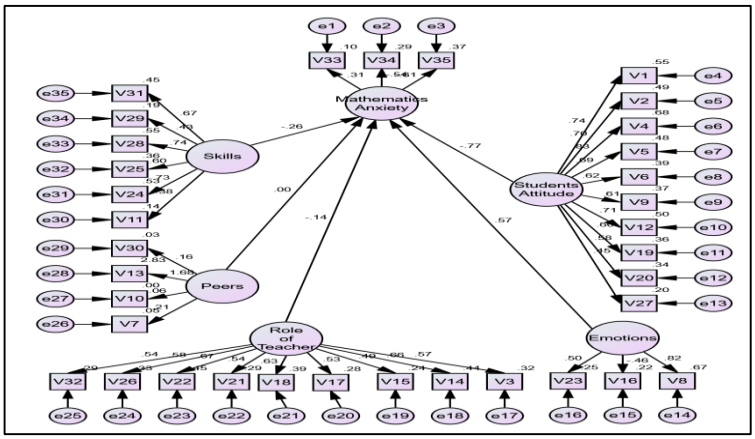

Figure 2: Hypothesized Measurement Model

Then, the goodness-of-fit test statistics were investigated. The value of Chi-square and the associated degrees of freedom show a good fit. However, all the values of CMIN/DF, GFI, AGFI, CFI, CRATIO and RMSEA do not fulfill the acceptable values, which indicate it is not a good fit model. Additionally, based on the Table 7 below, it can be seen that there are only two parameter (Students Attitude and Emotions) estimates are significantly differently 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 the regression estimates are comparable, which may assist us to pick up 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	

			Estimate	S.E.	C.R.	P	Label
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

We combined two constructs or more in order to get the fit model. Then, the goodness of fit test statistics has been checked until fulfilled all the acceptable value of indices. There are a few ways 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 fit well.

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 it was shown below. 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 are fulfill all the acceptable values.

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

From the tables below, 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.

3.5 Final Model

Combining all the constructs has developed final model or structural model. AMOS suggests the correlation structures between the constructs after the fitting of initial model without any correlated constructs. This helps improve the overall model fitting. Then, the validity of 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 had positive direct effect on mathematics anxiety. Meanwhile, students' attitude and skills had negative direct effect on Mathematics Anxiety. There was no direct effect of emotions on mathematics anxiety but had 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 had indirect effect through Students' Attitude.

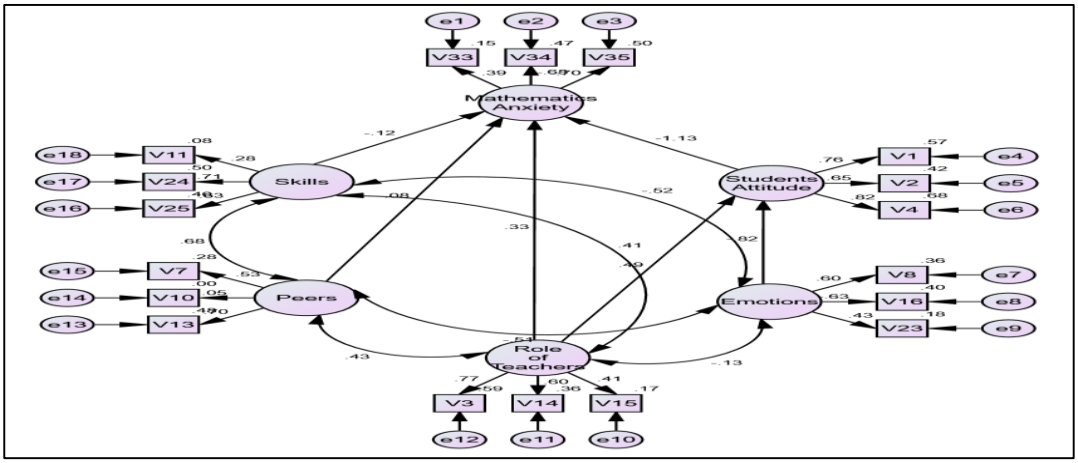

Figure 3: Structural Equation Model

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

			Estimate
Mathematics_Anxiety	<---	Peers	.081
Mathematics_Anxiety	<---	Role_of_Teachers	.328
Mathematics_Anxiety	<---	Skills	-.116

4. CONCLUSION AND DISCUSSION

In this study, we investigated the factors that contributed to mathematics anxiety among student in College S and College Z. We identified five factors, i.e. student's attitude, role of teachers, skills, emotion, and peers. In Factor 1 (students' attitude), most students were strongly agreed with this factor. They enjoy doing mathematics exercise during leisure time, referring to mathematics book and always memorize formula. They also always help other students to resolve mathematical problem.

In Factor 2 (role of teacher), results showed strong positive response from students. It can be assumed that students enjoyed and contented with current teaching method. They enjoyed encouragement from lecturers and discussion when having mathematics problem. 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 were confused by mathematics that has 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 friend or in a group to solve mathematics problems. Such practice is helpful while dealing with doubt during class. It can also increase confidence level in solving mathematical problems.

In summary the structural equation modeling adopted in this study found that all the factor to be 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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