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Development and Validation of a Mathematics Attitude Scale (MAS) for High School Students in Southern Philippines

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The purpose of this study was to develop an instrument that measures the attitude of the Filipino high school students towards mathematics with reliable predictors and factors. Using the responses of 300 high school students from Zamboanga Sibugay, the validity and reliability of the Mathematics Attitude Scale (MAS) was tested using Exploratory Factor Analysis (EFA) and reliability analyses. The factor analysis showed that four factor-structures of the instrument of the mathematics attitude for high school students explained 27.48% of the variance in the pattern of relationships among the items. The Average Variance Extracted (AVE), Composite Reliability, and Cronbach's Alpha coefficients were reported and proved that the extracted constructs have obtained and satisfied convergent validity. Thirty-three items remained in the final questionnaire after deleting the twenty-seven items which had factor loadings of less than 0.4. The four-factor structure of the Mathematics Attitude Scale (MAS) has been confirmed through this study.

Key words: *Mathematics attitude scale, exploratory factor analysis, reliability analyses, construct validity.*

Introduction

Problems regarding the declining interest of students in studying mathematics in schools becomes more acute, and this problem is also a generating vicious circle (Holton, 2009). Several studies reported different factors that lead to students' poor performance in mathematics. Tudy (2014) conducted the study to the Filipino students, and discovered that only attitude towards mathematics manifested significant influence to academic performance of the students. Students that have positive attitude towards the subject have the tendency to perform well. Therefore, developing a positive attitude towards the subject can improve the mathematics performance of the students in the Philippines.

Several existing studies showed factors that affect the attitude of the students towards mathematics. These factors are math-self efficacy, mathematics anxiety, motivation, parental influences, teacher affective support, and classroom instruction (Vukovic et al., 2013; Kerr, 2007; Mahamood et al., 2012; Marchis, 2011; Sakiz et al., 2012; Reyes & Stanic, 1988; Singh et al. 2002; Chamman & Callingham, 2013). The teachers have the strongest impact on the attitudes of the students towards mathematics. Attitudes are not stable, and it can vary in every teacher. Teachers who engage students in hands-on activities with real-world applications, who make students feel supported, who demonstrate passion for the subject, and who provide one-on-one attention have a positive effect on students' attitudes towards mathematics (Kelly D., 2011).

In improving students' attitudes to mathematics, teachers have employed different strategies in teaching. For instance, the utilisation of technology aided-instruction improved students' attitudes towards the subject (Choi et al., 2013). Even social networking sites helped in improving students' performance. The study by Gregory, Gregory & Eddy (2014) found out that those who participated in Facebook group discussion are more engaged in Mathematics subject. Using drawing activities also has a positive effect on the performance of students in mathematics (Arhin & Osei, 2013). The use of the guided hyper-learning method was also effective (Fathurrohman et al., 2013). Walkington, Petrosino & Sherman (2013) also discovered that context personalisation has a positive effect on improving academic performance in mathematics. Nonetheless, problems of low performance still emerge. One of the reasons why students performed poorly in mathematics was their attitude towards the subject. Some researchers proved that the students' attitude had a strong relationship with their academic performance (Parker et al., 2013).

Educators should give attention to students' attitudes towards mathematics in teaching the subject if one is serious in advancing the performance of the students. In doing this, the presence of a healthy environment is significant (Tran, 2012). In addition, the attitude, beliefs, and teaching style of the teacher, and the attitude of the parents were identified as explanation factors that account for the students' attitudes towards mathematics (Asante, 2012; Vukovic et al., 2013). Hence, there should be a positive learning environment so that students can develop a positive attitude towards the subject that would lead to better performance (Tran, 2012). Having the opposite is fatal. For example, negative feedback from teachers is the strongest predictor of students' mathematics self-efficacy (Thomas, 2013). If students are anxious about the subject, this will likely affect them. Ma (1999) saw a significant relationship between anxiety towards mathematics and achievement in mathematics.

The concept of attitude towards an object is very important in researchers involving the academic performance of the students. To understand the impact of students' attitude towards mathematics in the Philippines, it is essential to assess the construct with reliability and validity. Measuring the attitudes of the students towards mathematics is a complex process that involves many different variables, hence choosing a rigorous measurement model to construct a valid student attitude towards mathematics scale is crucial. Moreover, instruments that measure the mathematics attitude were not validated to the high school students in the Philippines but instead to the college students (Guce et al., 2013). The other available instruments of attitude scale towards mathematics were validated to foreign countries. One of the most popular foreign instruments utilised in research for the last three decades is the Fennema – Sherman Mathematics Attitude Scales consisting a group of nine (9) instruments developed in 1976. These nine (9) instruments are the following: (1) Attitude Toward Success in Mathematics Scale, (2) Mathematics as a Male Domain Scale, (3) and (4) Mother/Father Scale, (5) Teacher Scale, (6) Confidence in Learning Mathematics Scale, (7) Mathematics Anxiety Scale, (8) Effectance Motivation Scale in Mathematics, and (9) Mathematics Usefulness Scale. These instruments are too old which posed concerns for researchers in the Philippines. Researchers in this country have been dependent on adoption of foreign instruments to measure students' attitudes in their educational research (Tudy R., 2014). The items like "My parents pressure me to do my math assignment." and "I don't want to attend math classes with a strict teacher" were not included in the popular attitude instrument of the Fennema – Sherman Mathematics Attitude Scales (1976). However, these items were validated to the Filipino high school students and included in Mathematics Attitude Scale developed by this study. Furthermore, putting the diverse cultural heritage of Philippine society with many ethnic groups into consideration coupled with the fact that attitudes towards mathematics are influenced by societal norms (Mata, Monteiro, & Peixoto, 2012). It became paramount to develop an instrument using indigenous data for measuring the attitude of high school students. This research contextualised the instrument in order to obtain useful and reliable information about the mathematics attitudes of Filipino high school students. This study, therefore, stemmed from the measurement of students' attitudes towards mathematics using the indigenous data; this instrument has different components compared with the existing mathematics attitude scales. For this research, the Exploratory Factor

Analysis and Reliability Analyses were chosen to develop an attitude scale towards mathematics to obtain most useful information about the attitudes of Filipino high school students towards mathematics. The purpose of this research is to develop and validate an instrument that measures the attitude of the Filipino high school students towards mathematics.

This study developed a contextualised Five-Point Likert Scale that measures the attitude of Filipino high school students towards mathematics. The researchers used the Exploratory Factor Analysis to uncover the underlying structure of a set of variables and to identify a set of latent constructs underlying the measured variables. The reliability analyses were also applied in this study to determine the reliability of the measure. The results of this study are helpful in measuring the mathematics attitudes of the Filipino high school students, giving feedback to the teachers, improving the teaching-learning process and mathematics performance among the students.

Methodology

This study is a development and validation of the instrument by applying the Exploratory Factor Analysis (EFA) and reliability analyses; this instrument measures the mathematics attitude of the Filipino high school students. The design of the instrument is a Five-Point Likert Scale. The options of this scale are the following: strongly agree, agree, undecided, disagree, and strongly disagree.

Existing literature showed the relationships of these factors: math-self efficacy, math anxiety, motivation, parental influences, teacher affective support, and classroom instruction - to the attitude of the students towards mathematics. These six factors were the guide in identifying the real constructs or factors. The instrument was developed around these six factors. Each of these factors was constructed with 10 statements. This Five-Point Likert Scale underwent content validation, face validation, Exploratory Factor Analysis (EFA), descriptive statistics, and reliability analyses.

The study was conducted at Alicia National High School situated at the municipality of Alicia, Zamboanga Sibugay, Philippines. This high school has enrolled students from various tribes like Subanen, Cebuano, Ilonggo, Maranao, Maguindanao, Tausug, etc. The research participants of this study were 300 high school students. The researcher asked the permission from the School Division Superintendent through the principal in order to authorise the distribution of the Five-Point Likert scales to the high school students. The researcher also asked the consent of each student who participated in the study through the consent letters sent to the parents. After obtaining all the permissions from the school and participants, the researcher asked the class adviser/subject teacher of each section for permission to administer the questionnaires to the respondents. The participants responded to the questionnaires on how they agreed or disagreed with each of the statements. Their responses were examined, tallied, and subjected to the statistical process.

Results and Discussion

In performing the exploratory factor analysis, the univariate and multivariate normality within the data were checked as a requirement for the factor analysis (Child, 2006). The outliers and the normality of the distribution were also examined by inspecting the Normal Probability Plot of the regression standard residuals as part of the analysis in order to determine the outliers to be deleted. In the Normal P-P Plot, the expected value was compared to the value actually seen in the data set or observed value. In this study, the data is normally distributed and linear because the dots fall almost exactly on the straight line. This means that the observed values are same as from any normally distributed set. Moreover, based on the Box Plot, there are 64 outliers and were not included in the further analysis. The effect of multicollinearity is to reduce any single independent variable's predictive power by the extent to which associated with other independent variables. Multicollinearity was identified by examination of correlation matrix. In this study, there was no presence of high correlation (0.90 and higher); an indication of no multicollinearity (Hair et. Al, 2007).

After the outliers, normality of data and multicollinearity were checked, the Exploratory Factor Analysis was initially run. Principal Components analysis was utilised to extract maximum variance from the data set with each component. Thus, this reduced the large number of variables into a smaller number of components (Tabachnick & Fidell, 2007). This study used the orthogonal rotation, Varimax rotation, to minimise the number of variables that have high loadings on each factor and worked to make small loadings even smaller. Items with factor loadings below 0.4 were eliminated (Hair et. Al. 2010). Hence, out of 60 items, there were 27 deleted items and 33 remaining items. Table 1 presents the test for sampling adequacy and pattern relationship. The Kaiser-Meyer Olkin Measure of 0.704 is greater than the suggested threshold of 0.6 indicating sampling adequacy (Kaiser, 1974) and the Bartlett's Test of Sphericity, Approx. Chi-Square of 4028.83, $p< 0.05$ indicates correlations between items were sufficiently large for EFA.

All items except one have high communalities which indicates that the extracted components represent the variable well. Variables with greater than 0.5 communality were considered in further analysis while less than 0.5 were dropped (Hair et al., 1995). The Eigenvalues and the Final Four-Factor Structure are reflected in the Table 2 and the Scree Plot Criterion is also shown in the Figure 1. Table 2 shows that there are 20 initial factors whose eigenvalues are greater than or equal to one (Kaiser, 1960) and these 20 factors has a total percent of variance of 27.48%. That is the percent of variability explained by these 20 factors, with nearly

72.52 loss of information. Factors with eigenvalues greater than 1 were considered significant. However, Cliff (1998) states that the method is affected by the sampling error, and it tends to result in a great (excessive) number of factors when applied to the sample matrix.

Moreover, the Scree Plot (Figure 1) shows that the three factors to be retained. To solve these differences and to validate the result, the researcher used a third criterion, the Eigenvalue Monte Carlo Simulation using syntax codes in SPSS (Horn's parallel analysis). Table 3 presents the Parallel Analysis Criterion Test for factor extraction using Monte Carlo Simulation Technique in determining the number of factors.

Horn's parallel analysis was utilised to determine the number of factors in the exploratory factor analysis. The number of factors provided by this parallel analysis was compared to that of the factors obtained from eigenvalue and scree plot. Random data generation, which is parallel to the actual data set, is the basis for this parallel analysis. The Monte Carlo Simulation Technique was used to determine the number of factors and the comparison of eigenvalues of two data (Omay and Duygu, 2016). Actual eigenvalues were compared with random order eigenvalues in parallel analysis. Factors with actual eigenvalues that surpass random ordered eigenvalues are retained (Williams et al. 2010). As reflected, there are four retained factors.

Factor loadings were examined to determine the strength of the relationships. Factors were identified by the largest loadings, and it was also examined the zero and low loading in order to confirm the identification of the factors (Gorsuch, 1983). Items with factor loadings below 0.4 were eliminated (Hair et. Al. 2010). Hence, out of 60 items, there were 27 deleted items and 33 items were retained (Table 5). The results (Table 4) revealed that the variables are normally distributed based on the degrees of skewedness and kurtosis. The sample size of this study was larger than 200; thus, the rule of thumb (absolute value of less than 1) was also applied to test the normal distribution of the data (Field, 2009).

The Table 5 presents the items and final four-factor structure of the Mathematics Attitude Scale (MAS) after factor reduction procedures. As reflected, there are 4 factors with 33 items. The factor 1 represents the *Students' Perceived Motivation and Support in Learning Mathematics* with 12 items. The factor 2 represents *Students' Perceived Anxiety in Learning Mathematics* with 10 items. While the factor 3 is the *Students' Perceived Self-Efficacy in Learning Mathematics* with 6 items. And lastly, the factor 4 represents the *Teachers and Parents' Influences to Students in Learning Mathematics* with 5 items.

Anything that directs the behaviour of one's person to do something whether these are internal or external forces is called motivation (Ryan R. & Deci E., 2000). The item number 1

"It is important and valuable for me to get high grades in mathematics" talks about the significance of getting high grades. In order to get good grades in mathematics, students should motivate themselves to study hard in the subject. In addition, the item number 3 "Learning mathematics can assist me to find an excellent career in the future" is also a motivational factor that drives the students to learn mathematics. There are also other items that are considered motivational factors that encourage the students to learn mathematics. Item number 8 "My teacher encourages me to learn mathematics", number 10 "I learn mathematics more with the help of my supportive teacher", number 11 "My teacher gives positive feedback that boosts my confidence to perform better in my math class" talk about showing support to the students to learn mathematics well. Other items are perceived motivation and support of the students in learning mathematics.

Anxiety is a feeling of uneasiness and worry, usually generalised and unfocused (Bouras N. & Holt G. 2007). The statements number 13 "I am usually uneasy in math classes" and number 19 "I worry that I will not be able to answer the test in mathematics subject" show the anxieties of the students towards mathematics, and the other items also do the same. These items reflect the perceived anxiety of the students in learning mathematics because being uneasy in math class bothers the emotion of the students to learn math and being worried also hinders and disturbs the students in learning the subject.

Self-efficacy is an individual's belief in their innate ability to achieve something (Bandura A.1982). The items "I believe I can do good in mathematics", "I believe I can understand the mathematical concepts" and the other items show self-efficacy because having beliefs that one is good in mathematics, and one can understand the concepts in mathematics subject are evidences of being self-efficient in learning the subject. Thus, these items show the perceived self- efficacy of the students in learning mathematics.

Lastly, items "My parents stress the importance of mathematics" and "I don't want to attend math classes when my teacher is strict" show that parents and teachers influence the students. The ability of the students to perform well in the math class may be hindered or honed, but it depends on how the students are influenced by their teachers and parents. Because having parents who give value to the subject and a teacher who is strict can really influence the ability of the students to perform well in the math class. Therefore, these items show the teachers and parents' influences to students in learning mathematics.

Table 6 presents the reliability coefficients for each element of the Mathematics Attitude Scale (MAS). This includes the Number of Items, Cronbach's Alpha, Average Variance (AVE) and Composite Reliability of each factor. The convergent validity assesses the items related to the proposed construct. The Average Variance Extracted (AVE) was utilised to summarise the measure of convergent among items. A factor with an AVE of greater than 0.5

is acceptable, while an AVE of 4 is considered adequate convergent. Moreover, if AVE is less than 0.5, but a composite reliability is higher than 0.6, the convergent validity of the construct is still adequate (Fornell & Larcker, 1981). Results show that the composite reliabilities of factors "*Students' Perceived Motivation and Support in Learning Mathematics*", "*Students' Perceived Anxiety in Learning Mathematics", "Students' Perceived Self-Efficacy in Learning Mathematics*", and "*Students' Perceived Self-Efficacy in Learning Mathematics*" are 0.833, 0.788, 0.730, and 0.654 respectively. Hence, the convergent validity of these four factors are adequate (Fornell & Larcker, 1981). This indicates that the four factors represent the attitude of the Filipino high school students towards mathematics.

Cronbach 's Coefficient Alpha, the most popular indicator of internal consistency, was utilised in this study to evaluate the reliabilities of the measurement (Hair et al, 2006; Lee, 2001). Nunnally (1978) recommended that an acceptable level of coefficient alpha for a reliable scale is at least 0.70. The instrument underwent the test-retest reliability. After the conduct of the test-retest reliability, the Table 6 shows that the three factors "*Students' Perceived Motivation and Support in Learning Mathematics", "Students' Perceived Anxiety in Learning Mathematics*", and "*Students' Perceived Self-Efficacy in Learning Mathematics*" have Cronbach Alpha values of 0.729, 0.766, and 0.776 respectively. Hence, these three factors are reliable. While the fourth factor "*Teacher and Parents' Influences to Students in Learning Mathematics*" has the reliability value of 56.1 and is endorsed to be revalidated using Confirmatory Factor Analysis (CFA).

Limitations and Conclusion

There are three limitations in this study. The first limitation has relation to the statistical method. Exploratory Factor Analysis (EFA) is an advantageous statistical technique utilised to examine the psychometric properties and construct validity of an instrument. However, the EFA is not a sufficient method to test the theoretical foundations of the instrument; thus, a Confirmatory Factor Analysis (CFA) should be conducted to further the knowledge in this area. The second limitation of this study is the sampling bias. The sample was from the grade 9 and grade 10 students in one high school only. In this study, the sampling process might threaten the ability to generalise the results. The third limitation is not performing the contemporary counterpart analysis, like Item-Response Theory Approach, which will allow the researcher to calibrate items and measure persons independently.

The Mathematics Attitude Scale (MAS) can be utilised to provide feedback for the researchers and mathematics teachers about the attitude of the Filipino high school students towards mathematics. Moreover, this questionnaire can be used as a research instrument in studies that involve information of the Filipino high school students with regards to their attitude towards mathematics.

Figure 1. Scree Plot Criterion

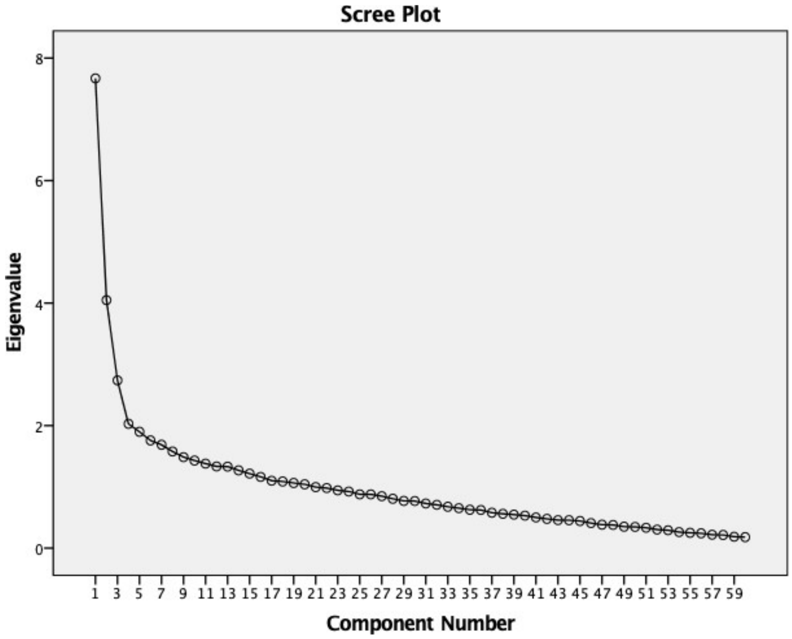

Table 1: Test for Sampling Adequacy and Patterned Relationship

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.704
Bartlett's Test of Sphericity	Approx. Chi-Square	4028.83
	df	1770
	p-value	0.00

Note: KMO > 0.6 = the sample is adequate
Bartlett's Test of Sphericity, significant level of p < .05

Table 2: Eigenvalues, Total Variances Explained for the Final Four-Factor Structure

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.67	12.78	12.78	7.67	12.78	12.78
2	4.05	6.75	19.53	4.05	6.75	19.53
3	2.74	4.56	24.10	2.74	4.56	24.10
4	2.03	3.38	27.48	2.03	3.38	27.48
5	1.90	3.17	30.64	1.90	3.17	30.64
6	1.76	2.93	33.57	1.76	2.93	33.57
7	1.69	2.81	36.38	1.69	2.81	36.38
8	1.58	2.63	39.01	1.58	2.63	39.01
9	1.49	2.48	41.49	1.49	2.48	41.49
10	1.43	2.38	43.87	1.43	2.38	43.87
11	1.38	2.30	46.17	1.38	2.30	46.17
12	1.33	2.22	48.39	1.33	2.22	48.39
13	1.33	2.22	50.61	1.33	2.22	50.61
14	1.27	2.12	52.73	1.27	2.12	52.73
15	1.22	2.03	54.75	1.22	2.03	54.75
16	1.16	1.94	56.69	1.16	1.94	56.69
17	1.10	1.83	58.52	1.10	1.83	58.52
18	1.09	1.81	60.34	1.09	1.81	60.34
19	1.06	1.77	62.11	1.06	1.77	62.11
20	1.04	1.74	63.84	1.04	1.74	63.84

Note: Extraction Sums of Squared Loadings, Total, ≥ 1 = retained factors

Table 3: Parallel Analysis Criterion Test for Factor Extraction

Component Number	Actual Eigenvalue from PCA	Random Order from Parallel Analysis	Decision
1	7.67	2.28	Accept
2	4.05	2.14	Accept
3	2.74	2.05	Accept
4	2.03	1.98	Accept
5	1.90	1.90	Reject
6	1.76	1.84	Reject
7	1.69	1.78	Reject
8	1.58	1.71	Reject
9	1.49	1.68	Reject
10	1.43	1.62	Reject

Note: actual eigenvalues > random ordered eigenvalues = retained factors

Table 4: Descriptive Statistics of Each Element of Mathematics Attitude Scale

	M	SD	Skewness	Kurtosis	Min	Max	N
1. Students' Perceived Motivation and Support in Learning Mathematics	2.41	0.49	0.22	0.60	1.25	4.17	236
2. Students' Perceived Anxiety in Learning Mathematics	2.83	0.44	0.07	0.17	1.7	4.2	236
3. Students' Perceived Self-Efficacy in Learning Mathematics	2.90	0.55	-0.04	-0.04	1.33	4.33	236
4. Teacher and Parents' Influences to Students in Learning Mathematics	3.07	0.56	-0.58	0.64	1	4.2	236

Note: skewedness and kurtosis < I 1 I = normally distributed

Table 5: The Items and Final Four-Factor Structure of the Mathematics Attitude Scale (MAS) after Factor Reduction Procedures

		Factor			
		1	2	3	4
Factor 1: *Students' Perceived Motivation and Support in Learning Mathematics*					
1	It is important and valuable for me to get high grades in mathematics.	0.498			
2	I seek the help of others if I find difficulty in learning mathematics.	0.493			
3	Learning mathematics can assist me to find an excellent career in the future.	0.495			
4	Learning mathematics will develop me as critical thinker.	0.523			
5	My parents think learning mathematics is important.	0.632			
6	My parents are happy to see my good grades in mathematics.	0.626			
7	I am interested to learn mathematics when my teacher praises me.	0.463			
8	My teacher encourages me to learn mathematics.	0.623			
9	I like to learn math with my approachable teacher.	0.551			
10	I learn mathematics more with the help of my supportive teacher.	0.560			
11	My teacher gives positive feedbacks that boost my confidence to perform better in my math class.	0.513			
12	I really like to engage in math discussion if the topic interests me.	0.520			
Factor 2: Students' Perceived Anxiety in Learning Mathematics					
13	I am usually uneasy in math classes.		0.529		
14	I am not good in mathematics.		0.599		
15	I study math but it really seems difficult for me.		0.512		
16	My mind becomes blank and unable to think clearly when working in mathematics.		0.540		
17	I hate mathematics subject.		0.491		
18	I cannot solve difficult math problems.		0.539		
19	I feel worried that I will not be able to answer the test in mathematics subject.		0.561		
20	I get tense when there is an announcement of schedule of math test.		0.538		
21	I get nervous when taking a mathematics test.		0.449		
22	I like to solve new mathematical problems.		0.445		
Factor 3: Students' Perceived Self-Efficacy in Learning Mathematics					
23	I believe I can do good in mathematics.			0.632	
24	I think I am the type of student who actively participates in math activity.			0.620	
25	I believe I can get a good grade in a mathematics subject.			0.468	
26	I work hard in my mathematics classes.			0.500	
27	I believe I can understand the mathematical concepts.			0.570	
28	I love solving mathematics problems.			0.550	
Factor 4: Teachers and Parents' Influences to Students in Learning Mathematics					
29	I perform well in math class when my parents support me.				0.438
30	My parents pressure me to do my math assignment.				0.588
31	My parents stress the importance of mathematics.				0.435
32	I don't want to attend math classes with a strict teacher.				0.573
30	Mathematics class is dull and boring.				0.579

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations.

Table 6: Reliability Coefficients for Each Element of the Mathematics Attitude Scale (MAS)

Factor	Number of Items	Cronbach's Alpha	Average Variance Extracted (AVE)	Composite Reliability
1. Students' Perceived Motivation and Support in Learning Mathematics	12	0.729	0.296	0.833
2. Students' Perceived Anxiety in Learning Mathematics	10	0.766	0.273	0.788
3. Students' Perceived Self-Efficacy in Learning Mathematics	6	0.776	0.313	0.730
4. Teacher and Parents' Influences to Students in Learning Mathematics	5	0.561	0.278	0.654

Note: Average Variance Extracted is less than 0.5, but composite reliability is higher than 0.6, the convergent validity of the construct is still adequate. Composite reliability ≥ 0.6 = acceptable

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