

## A mathematical anxiety scale instrument for junior high school students

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### ABSTRACT

Anxiety becomes one of the psychological symptoms that can appear in every student while solving mathematics problems. Anxiety cannot be denied to be one factor that affects students' learning outcomes and interest in mathematics. Therefore, teachers should concern on this matter in order to decide the appropriate learning strategy. However, there is no instrument to measure the level of students' anxiety towards mathematics, especially for junior high school students. For that reason, this research aims to: 1) design the construct of math anxiety scale instrument, 2) find out the validity of the instrument. This research used Research and Development method to develop and validate the product which is in the form of a questionnaire. The analysis techniques used V Aiken for content validity, EFA for construct validity, and Cronbach's Alpha for the reliability. The results of this research showed that the instrument was valid and reliable because it met the criteria for validity and reliability. In conclusion, the instrument is valid to measure the junior high school students' math anxiety level.

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## 1. INTRODUCTION

The development of science and technology allows all parties to obtain information quickly and easily from various sources throughout the world. One of the subjects that is relevant to the development of this era is mathematics. Understanding and mastering mathematics material for students is a necessity to face increasingly competitive global competition. But, the presence of these subjects was not welcomed by some students. Anxiety in these subjects, often occurs in some students in school, both when learning mathematics, and mathematics evaluation.

One psychological symptoms that can appear in every human being is anxiety. According to Bellack and Hersen, the word 'anxiety' is derived from Latin (anxius) and German (anst) which refer to a word used to describe negative effects and physiological stimuli [1]. Anxiety occurs when there is a situation or a certain unreal object which is considered as frightening or threatening by someone. This situation can happen to some students at school. The anxiety faced by students often relates to their learning problems. One of the subjects that most students do not like is mathematics. Even some of them try to avoid this subject since it is considered as the most difficult one. As a result, they feel anxious when facing a mathematics problem.

According to Holmes, mathematical anxiety is a negative cognitive reaction from someone when he or she deals with mathematics [2]. Trujillo and Hadfield define it as a discomfort situation that occurs in response to situations involving mathematical tasks which are believed to threaten self-esteem [3]. Arem also states that people who experience this anxiety have an irregular, confused, and unsafe feeling while they also

experience shortness of breath, muscle tightness or other physical symptoms [4]. According to Sheffield and Hunt, it is considered as an anxiety feeling which happens to many individuals while facing mathematical problems [5]. Some indicators of this include a faster heartbeat and a belief they are unable to solve the problems or they try to avoid the math lessons.

Mathematical anxiety has a different definition compared to other forms of anxiety since it is defined as emotional responses generated by students towards mathematics. However, other forms of anxiety are often associated with mathematical anxiety in practice. For example, test anxiety is related to fear in evaluative settings [6, 7]. Anxiety often occurs in students at their teen ages. At this age, students experience psychosocial changes which are divided into three stages, namely early, middle and final adolescents. The early stage happens at the age of 12 to 15 years [8, 9]. The characteristics of this stage are some psychological changes such as identity crisis, an unstable soul, increased ability to express themselves, highlighting the importance of friends, pointing at parents' mistakes, a tendency to be childish, etc. The anxiety feeling is strong in this stage. It is categorized as an unstable soul and becomes one form of self-expression about something that can be expressed. Ages 12 to 15 years are at the junior high school level. Therefore, junior high school students were chosen to be the subjects of this research.

Based on the results of a preliminary study involving five mathematics teachers in several junior high schools, it is found that an assessment should not only focus on the knowledge aspects but also on attitudes and skills. It is emphasized in the Regulation of the Ministry of Education and Culture number 22 in 2016. It is stated that an assessment should cover three aspects at once. The aspects include knowledge, attitudes, and skills; and all of them are interrelated. Teachers can measure the knowledge aspect from the students' learning outcomes. Meanwhile, they should make or adopt an instrument from the curriculum in order to measure the attitude and skill aspects. Nevertheless, the instrument exemplified by the government is deemed incapable of providing in-depth information about the students' actual state.

The teachers concluded that some students often experience anxiety when mathematics classes or evaluation takes place. They show various indicators and it should be highlighted by the teachers. It affects the learning styles which should be applied during the learning process. Therefore, a teacher should understand about mathematics anxiety and apply the appropriate learning strategies in order to make students overcome their anxiety [10]. The estimated number of students who experience math anxiety based on the observation results is shown in the following Figure 1.

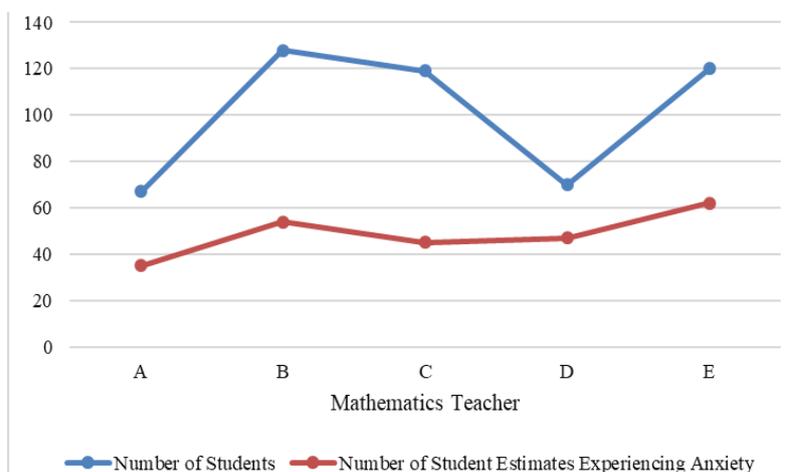


Figure 1. Result of observation from mathematics teachers

The interview results inferred that a mathematics teacher should be able to make an instrument to measure the students' level of anxiety. It is observed that students with medium to high ability in mathematics tend to experience the anxiety rather than those who have a lower ability since they tend to put less concern on this subject. On the other hand, teachers were still confused about the instrument to be used. Assessing attitudes related to anxiety needs some components in its development. Some instruments for children and adolescents have been developed and applied. Many studies on mathematical anxiety have been conducted in elementary schools, high schools and tertiary levels of university students [11, 12]. However, the statistical process used in some steps of the development was limited to a certain age or the data which support validity was not supported.

The example is a study by Ramirez et al. who used an eight-point questionnaire developed for children [13]. The question referred to the anxiety in a particular mathematical problem, for instance, "How would you feel if you were given this problem? There are 13 ducks in the water. There are six ducks on the grass. How many ducks are there?" This instrument was clearly appropriate only to young children. Apart from their anxiety, the instrument only showed a simple problem. In addition, the authors only reported the reliability statistics and left size validity as an issue. A good assessment instrument should be well-designed and empirically evaluated to ensure the accuracy of users' information. A good test must fulfill three characteristics, including validity, reliability, and reusability [14]. An instrument is said to be valid if it actually measures what it should measure and what is to be measured.

## 2. RESEARCH METHOD

### 2.1. Research design

This study is a research and development (RnD) study aimed to develop and validate products in the form of anxiety scale questionnaires. The results of the interview with five teachers and a study about anxiety were used as the materials to make the questionnaire framework. The purpose of this study was to produce an instrument to measure the level of mathematical anxiety felt by early adolescent students. It was developed in the form of a questionnaire using the Likert scale concept without neutral options. Thus, the four scales are always (4), often (3), rare (2), and never (1).

This research used a non-test instrument development model consisting of 10 steps. However, there were only eight steps used, including 1) determining the instrument specification, 2) writing the instrument, 3) determining the scale of the instrument, 4) determining the scoring system, 5) examining instruments, 6) trials, 7) instrument analysis, 8) re-assembling instrument. In developing this instrument, the researcher made an instrument construct based on the theory of response to anxiety according to Stuart, the instrument framework and the developed indicators [15]. The development of this product began with interviews and materials study until the appropriate indicators and points are determined.

### 2.2. Participant

This study involved 257 junior high school students. They are from four schools spread in the Surakarta, Sukoharjo, and Yogyakarta with the total are seven class. From these seven classes, researchers did not pay attention to the comparison of the number of men and women, and considered all students with mathematical abilities who were based on the information obtained by their mathematics teacher.

### 2.3. Data collection and analysis techniques

In the data collected were in the form of quantitative data which is supported by qualitative data. The data collection technique used anxiety scale in the form of questionnaires and interviews. After the instrument is assembled, the items were validated in term of content by 7 raters. The results of the assessment are analyzed with the V Aiken formula, as follows [16, 17]:

$$V = \frac{\sum S}{[n(c-1)]}$$

Based on these assessments, there were some items dropped. Then, a trial was carried out in the field in order to test the compatibility of the items with a model (item fit test) and to test the construct and reliability of the instrument.

## 3. RESULTS AND ANALYSIS

The development of this instrument was based on a preliminary study conducted by interviewing with five mathematics teachers and doing materials study from several previous studies. Based on the results of the interview, it is found that an assessment carried out by teachers should not only focused on the students' knowledge, but also on their attitudes and skills. However, there is a lack of instruments which measure the aspects of attitudes and skills. In addition, there is also a lack of instruments which measure some things that the teachers want to know.

### 3.1. Mathematical anxiety instrument framework

Based on the theory of anxiety symptoms by Stuard and Sunden, there are four aspects of anxiety with different indicators for each aspect. Thus, the instrument framework of mathematics anxiety scale questionnaire was developed as shown in Table 1.

Table 1. Mathematical anxiety instrument framework

Theory	Aspects	Indicators
Students' Mathematical Anxiety	Physiological Responses in Mathematics learning or evaluation process	Faster heartbeat Heavy head feeling Feeling like about to faint A more frequent breathing activity Breathless Feeling a chest Walking back and forth in the classroom Facial tension Having a stomachache Twisted stomach Difficulty swallowing Often asking for permission to use the restroom Blushing face Sudden sweaty hands Cold sweats Muscle ache Teething teeth Unstable Voice
	Behavioral Responses in Mathematics Learning or Evaluation	Shocked reaction Talking faster or nervously Like to avoid problems Excessive alert After the exam, still feeling guilty about the answer Worrying about something bad to happen Feeling shamed to other people to ask about mathematical materials
	Cognitive responses in mathematics learning or evaluation	Losing of objectivity when facing difficult problems Often determining the wrong answer Unsound sleep Feeling confused when facing math problems alone. Easy to lose concentration Often feeling confused in the process of mathematics evaluation Feeling afraid of the result the evaluation Feeling move afraid to face the mathematics test rather than the other subjects
	Affective Responses in Mathematics Learning and Evaluation	Suddenly forget the subject matter when they are pressed by time After the exam, still feeling guilty about the answer Worrying about something bad to happen Feeling shamed to other people to ask about mathematical materials

### 3.2. Item distribution

The framework above was developed into 35 statement items that refer to mathematics learning anxiety and mathematical evaluation anxiety. Then, these items are spread in four aspects. The distribution and numbers of each aspect are presented in Table 2.

Table 2. Item distribution of mathematical anxiety instrument

Aspects	Statement Items	Total
Physiological Responses	1, 2, 3, 4, 5, 6, 7, 8, 9, 10,	10
Behavioral Responses	13, 14, 15, 16, 17, 18, 19, 20, 21,	9
Cognitive Responses	11, 12, 22, 23, 31, 32, 35	7
Affective Responses	24, 25, 26, 27, 28, 29, 30, 33, 34,	9
Total		35

Based on the Table 2, it can be known that the number of items that can be from a construct are 35 statements. These items consist of two types of statements, namely positive items and negative items. Thus, the following scales are used to determine the level of mathematical anxiety of the first high school students.

Based on the scoring scale that presented in Table 3, the assessment rubric for mathematical anxiety of junior high school student's is in the following in Table 4.

Table 3. Scoring scale for student’s mathematical anxiety

Scoring Scale	Item Type of Statement	
	Positive	Negative
4	Always do as stated	Never did
3	Often do as stated but have done it	Rarely do the statement but have done it
2	Rarely do the statement but have done it	Often do as stated but have done it
1	Never did	Always do as stated

Table 4. Category of student’s mathematical anxiety

Total Score	Category
$105 < X \leq 140$	Very High
$70 < X \leq 105$	High
$35 < X \leq 70$	Low
$0 < X \leq 35$	Very Low

Based on the table above, the mathematical anxiety value of students is considered to be in the category if it reaches the numbers at the predetermined interval of scores from the execution of this instrument.

**3.3. Content validity**

This instrument was validated by seven raters using three scales. The results of the validator data were analyzed by using V Aiken formula for the content validity. The following graph in Figure 2 shows the distribution of V Aiken value for 35 items.

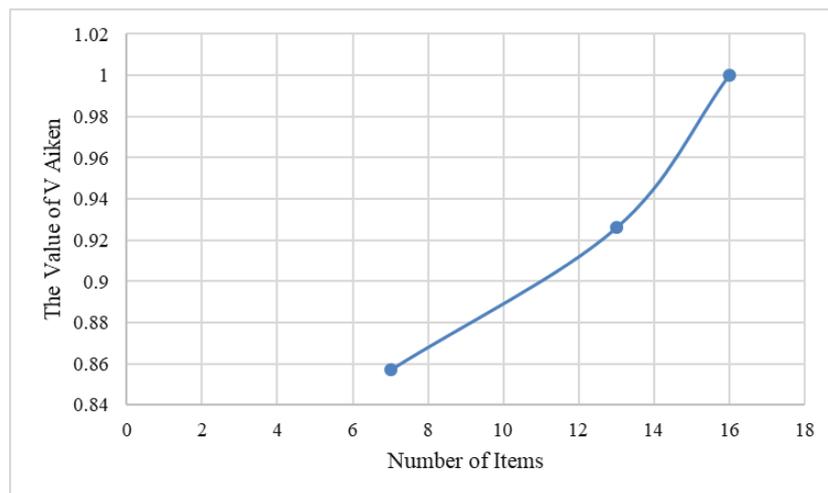


Figure 2. V aiken value distribution

The V Aiken value for 64 items which are shown in Figure 2 is various. Based on the Figure 2, it can be said that not all items are in the valid category. Referring to the Aiken table, the V Aiken value for an instrument with seven raters and three scale options is 0.857 for a 5% error rate [18]. Therefore, there are 11 items which were dropped because the V Aiken values were <0.857 and were considered invalid.

**3.4. Item analysis**

After that, the items were arranged again and numbered into 1 to 51. The next step is testing the compatibility of the items with the model fit test as shown in Figure 3.

Item Fit  
all on all (N = 257 L = 35 Probability Level = .50) 16/ 4/19 10:53

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INFIT

MNSQ	.56	.63	.71	.83	1.00	1.20	1.40	1.60	1.80
1 item 1			~~~~~		▲				
2 item 2			~~~~~		▲				
3 item 3			~~~~~		▲				
4 item 4			~~~~~		▲   ▲				
5 item 5			~~~~~		▲				
6 item 6			~~~~~		▲				
7 item 7			~~~~~		▲				
8 item 8			~~~~~		▲				
9 item 9			~~~~~		▲   ▲				
10 item 10			~~~~~		▲				
11 item 11			~~~~~		▲   ▲				
12 item 12			~~~~~		▲				
13 item 13			~~~~~		▲   ▲				
14 item 14			~~~~~		▲				
15 item 15			~~~~~		▲   ▲				
16 item 16			~~~~~		▲				
17 item 17			~~~~~		▲				
18 item 18			~~~~~		▲				
19 item 19			~~~~~		▲				
20 item 20			~~~~~		▲				
21 item 21			~~~~~		▲				
22 item 22			~~~~~		▲				
23 item 23			~~~~~		▲				
24 item 24			~~~~~	▲	▲				
25 item 25			~~~~~		▲				
26 item 26			~~~~~		▲				
27 item 27			~~~~~		▲				
28 item 28			~~~~~		▲				
29 item 29			~~~~~		▲				
30 item 30			~~~~~		▲				
31 item 31			~~~~~		▲				
32 item 32			~~~~~		▲				
33 item 33			~~~~~		▲				
34 item 34			~~~~~		▲   ▲				
35 item 35			~~~~~		▲				

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Figure 3. Results of fit item analysis

According to the table above, 51 items are considered as fit or match the Rasch model or 1-PL model with the acceptance limits of  $\geq 0.77$  to  $\leq 1.30$ .

Item fit analysis provides an illustration in the form of Item Characteristic Curves as presented in Figure 4. This graph illustrates the pattern of students' answers towards math anxiety items in number 1. The answer patterns of all students are within the boundaries of the infit and outfit acceptance space. The result of this graph supports the analysis of item compatibility with the Rasch model and shows that the items provide a pattern of answers.

The graph of Figure 5 shows the shape of the curve that is increasingly centered. It shows that the instrument is considered good for the participants with a moderate level of anxiety. The next step is testing the construct validity to see the factors which form the theory.

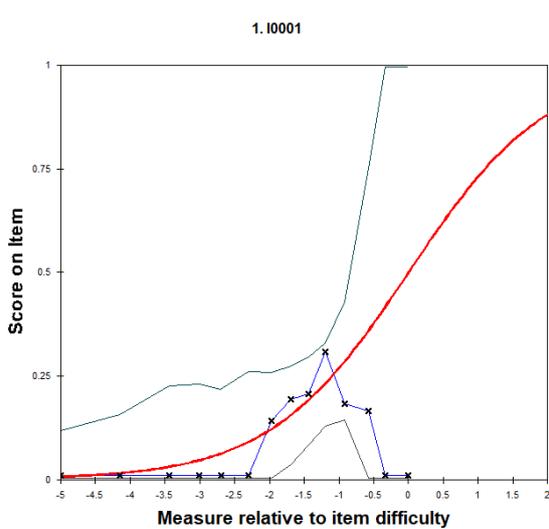


Figure 4. Example characteristics curves 1

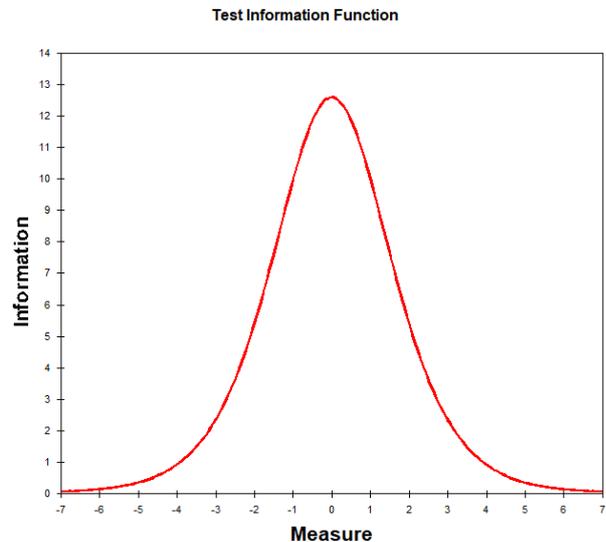


Figure 5. Example of test information function Curve

### 3.4. Construct validity

Based on the results of the EFA analysis (Exploratory Factor Analysis), Table 5 shows that the value of KMO-MSA of the data is 0.703 ( $> 0.5$ ) which means that factor analysis can be continued. In addition, the value of Bartlett's Test of the Sphericity with the sample size of 257 used in this study is sufficient. Then, the Chi-Squared approach value is 1069.7 and the significance value is 0,000 ( $< 0.05$ ). It means there is a correlation between the items and they can be processed further. Next, the value of the MSA in the Anti Image Correlation section for 35 items fulfills the prerequisites ( $> 0.5$ ). Therefore, it can be said that all the remaining items, which represent several factors that influence the attitude of mathematical anxiety, can be further processed.

Table 5. Value of KMO-MSA

Number	Criteria	Value	Requirement	Conclusion
1	<i>Kaiser-Meyer-Olkin Measure of Sampling Adequacy</i>	0.703	$> 0.5$	√
2	<i>Chi Kuadrat</i>	1069.668	-	-
3	<i>Significance</i>	0.000	$< 0.05$	√
4	<i>Anti Image Correlation</i>	0.560 – 0.851	$\geq 0.05$	√

Based on the output of Communalities, item 1 contributes 61.5% to the factors formed, point 2 contributes 54.3% to the factors formed, item 3 gives a contribution of 52.1% to the factors formed, item 4 gives contribution of 55.4% to the factors formed, item 5 gives a contribution of 61.7% to the factors formed, and so on until all 35 items give substantial contributions because they are in the range of 44% - 69.7%.

The next step is to determine the number of factors of the construct instrument that have been formulated. Table 6 shows the value of the factors formed from the results of the Exploratory Factor Analysis (EFA).

Table 6. The result of exploratory factor analysis

Component	Initial Eigenvalues			Extraction Sum of Square Loading		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.058	11.593	11.593	4.058	11.593	11.593
2	1.774	5.069	16.662	1.774	5.069	16.662
3	1.607	4.590	21.252	1.607	4.590	21.252
4	1.507	4.305	25.557	1.507	4.305	25.557
5	1.391	3.976	29.533	1.391	3.976	29.533
6	1.341	3.831	33.364	1.341	3.831	33.364
7	1.283	3.667	37.030	1.283	3.667	37.030
8	1.275	3.642	40.672	1.275	3.642	40.672
9	1.211	3.459	44.132	1.211	3.459	44.132
10	1.164	3.326	47.457	1.164	3.326	47.457
11	1.151	3.288	50.745	1.151	3.288	50.745
12	1.109	3.169	53.914	1.109	3.169	53.914
13	1.051	3.002	56.916	1.051	3.002	56.916

Based on the Table 6 shows that there are thirteen factors of the construct of this mathematical anxiety instrument. These factors have eigenvalues with a range of 1.051 - 4.058. From the beginning of eigenvalues in the cumulative sub column, looking that solving of destroying 35 points to be 1 factor can explain 56.916% varieties. Eigen value shows the relative importance of each factor in calculating the thirteen variances of the items analyzed. The number of eigenvalues for the thirteen variables is the same as the thirteen total variance of the variable. Kaiser and Hattie state that the most common strategy for making unidimensional claims is to maintain factors with eigenvalues greater than 1, even though this idea received a lot of criticism from some figures. However, several factors that have eigenvalues greater than 1 can be used as a unidimensional index [19, 20]. This is also strengthened by the results of the scree plots that form the elbows and is seen as one dominant factor as shown in Figure 6.

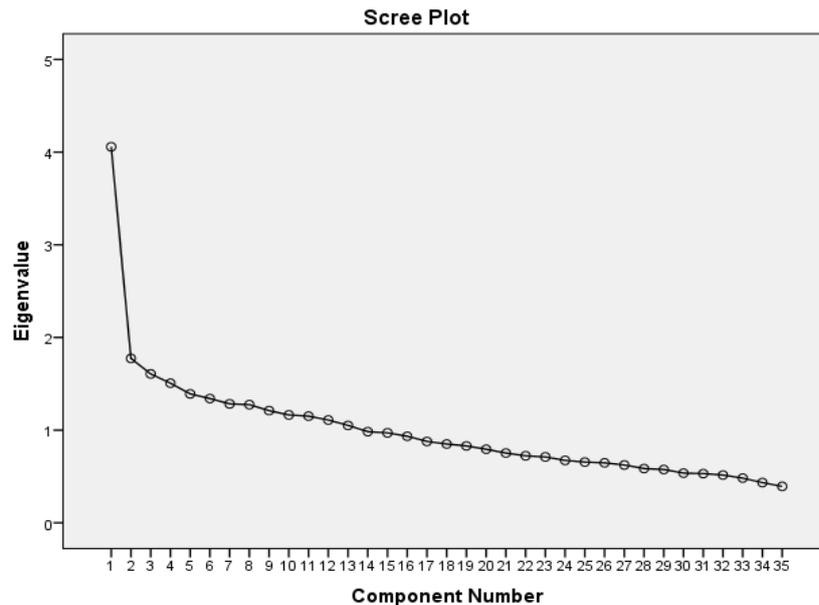


Figure 6. Example of test information function curve

As stated by Hambleton and Rovinelli, to determine the number of factors in a test instrument, one of the ways is by looking at the shape of the scree plot [21]. If it forms an elbow, then the number of Eigen that is on the left elbow is considered to be the most dominant and significant factor. Therefore, it can be said that the instrument has one factor or one dimension (unidimensional). The next step is to determine the level of reliability of the questionnaire. Reliability values can also be seen from the summary output statistics with Cronbach's Alpha reliability. The higher reliability value means a higher level of consistency of the instrument in assessing students' mathematical anxiety.

The Table 7 shows that the value of Cronbach's Alpha is 0.756. It means that 75.6% of the observed score variance resembles the true score variance. According to the literature, the reliability value of 0.756 indicates that the instrument has good reliability [22-25]. Thus, the instrument which was developed can be said to have good reliability.

Table 7. Reliability

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.756	.760	35

#### 4. CONCLUSION

The results of this study show that: 1) the framework of mathematical anxiety scale questionnaires has been developed based on Stuart and Sunden's theory of anxiety in which the symptoms of anxiety shown by students can be physiological, behavioral, cognitive and affective responses. There are 35 items of the instruments which are considered as valid. 2) The mathematics anxiety scale questionnaire that has been tested theoretically and empirically is feasible to use based on the V Aiken validity test and Rasch model analysis. The questionnaire with four scales fulfilled the Aiken validity criteria from 7 raters by obtaining a validation value ranged from 0.857 to 1.00. This instrument is also said to be fit for 35 items because each item has fulfilled more than one criterion of fit item. The reliability test results of the instrument have a value of 0.756. Therefore, this questionnaire is categorized as good to be used from time to time for several respondents. It can be used by junior high school teachers who want to know the symptoms of anxiety which are felt by their students while facing math learning or math exams. As a result, the teacher can find out the students' characteristics and interest, as well as is able to apply the appropriate mathematics learning strategies. Provide a statement that what is expected, as stated in the "Introduction" chapter can ultimately result in "Results and Discussion" chapter, so there is compatibility. Moreover, it can also be added the prospect of the development of research results and application prospects of further studies into the next (based on result and discussion).

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