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# Adaptation and validation of mathematics anxiety: Rasch and network psychometrics analysis

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**Abstract.** The purpose of learning process is achieved if there is a change of paradigm, mindset, and behaviour of students. This is also happening in the process of mathematics subject. Concepts, applications and analysis are needed in achieving the goals of learning mathematics. However, various variables can affect the process of transformation of learning materials, such as the condition of students' anxiety toward math subject. Deep exploration and analysis of the anxiety condition is needed to observe the student's difficult condition at the time of study and after the learning process. For that purpose, it needs a robust measuring tool in estimating students' mathematical anxiety conditions. This research aims to adapt and validate the inventory of Mathematics Anxiety Rating Scale - Elementary Form (MARS-E) through systematic methods. The study involved 127 students from grades 3<sup>rd</sup> to 6<sup>th</sup> elementary schools. The findings of the research indicate that MARS-E is valid and reliable measurement tools that can measure students' anxiety condition toward mathematics, the condition of connectivity between items presented through network analysis, and anxiety level through Rasch analysis. The findings of this research are believed to be disseminated at the elementary schools in Indonesia.

## 1. Introduction

The complexity of the learning process is the basis of the many studies to achieve the optimization of student learning outcomes [1], [2]. Many variables that determine the success of students in the learning process, especially when students are still in elementary school [3]. Mathematics as one of the important subjects in elementary school is not spared from the complexity and factors that influence it. In general, the achievement of students in learning mathematics is often a reference whether students need additional attention or vice versa [4]–[9]. However, the condition of achievement of elementary school student learning outcomes in Indonesia still needs further improvement. Based on PISA research in 2015 at 15-year-olds, shows that Indonesia's achievement in mathematical performance is ranked 64 out of 72 countries with a score of 386 [4]. This is what makes mathematics a serious concern in the learning process.

Learning problems experienced by students are not derived from single factor. In-depth analysis of the acceptance conditions of the subject matter needs to be done, especially in the diagnosis of learning difficulties [10], [11]. The condition of student acceptance of the subject matter is one of them influenced by psychological condition [5], [12], [13]. The mental health condition of the students is a major factor in analyzing students' learning difficulties [14]. Important factors are derived from the condition of students' anxiety toward mathematics, which this condition causes tension in students to



mathematics lessons, both at the time of the learning process and in its application in everyday life. In general, students' anxiety will be the main factor of rejection in the learning process, avoidance of all mathematical contexts, psychosomatic reactions ranging from mild to severe, inability to optimize the role of memory in the learning process, loss of motivation, ignorance of learning achievement, and other risky conditions [14].

An important diagnostic process is undertaken to eliminate possible learning difficulties derived from anxiety conditions. The knowledge of the level of anxiety becomes an absolute requirement to conduct a thorough analysis of the student's condition [10]. This leads to the need for a measuring instrument for estimating students' precise and robust levels of anxiety. For that purpose, it is necessary to study the students' anxiety measure in the mathematics lesson and the condition of validity and reliability will be obtained, which in turn will lead to an accurate level of anxiety level.

## 2. Method

### 2.1. Participants

This research involves students from grade 3<sup>rd</sup> to 6<sup>th</sup> grade of elementary school that consist of 127 students. The sample size is based on power measurement to avoid  $\alpha$  and  $\beta$  errors [15], so that the minimum number of samples with actual power 0.95 and effect size 0.8 is 70 respondents, with the number of samples in this research the requirement of measurement strength and statistical strength have been fulfilled. Furthermore, in a methodological perspective, the sample has represented every level of elementary school proportionately.

### 2.2. Measuring and Procedures

Mathematic anxiety was measured using the Mathematic Anxiety Rating Scale - Elementary Form (MARS-E) Indonesian Version, which is an adapted of the German version [5]. This inventory has been adapted in various languages, including English. In this study, adaptations were made to conform to Indonesian culture in general, so some were shortened by keeping in reference to the original source [16]. This inventory consists of two main aspects, the scale that measures students' cognitive and affective abilities. Validation procedure is done by using Rasch analysis, where this measurement can accurately examine the condition of reliability components, validity, rating scale validity, separation index, item fit, item difficulty and test of information function. Item Response Theory (IRT) method on Rasch analysis has the advantage of being able to provide linear measurements, exposing missing data, having accurate precision in measuring items, calculating outlier data, and providing independent instruments of the parameters studied. In addition, this research also uses network psychometrics method to estimate interaction between items in measuring students' general anxiety condition [17].

### 2.3. Data Analysis

The findings of research data were analyzed by using Rasch models [17], which used Winstep Version 3.72 software [18]. In addition, network psychometrics analysis was performed using JASP Version 0.8.6.0 [19]. Research data can be accessed in open source through the Open Science Framework [20].

## 3. Result and Discussion

### 3.1. Reliability

The consistency of item and person data about mathematical anxiety is presented in Table 1. The reliability condition of the items is indicated by the reliability item value of 0.96, it can be concluded that in general the items in Indonesian version of MARS-E are reliable ( $> 0.67$ ). The condition of the separation index item indicates that the variability of the item group is quite good (above 3.0), and indicating the diversity of the items. While the value of separation index in person is at the value of 2.79, can be interpreted that the condition is sourced on the source data is quite homogeneous and specific, which is elementary school students. When viewed from the interaction between items with

person, the value Cronbach  $\alpha$  (KR21) is 0.91, it can be interpreted that there is consistency answers on the item.

**Table 1.** Reliability testing of MARS-E using Rasch measurement analysis

	Mean	SD	Separation Index	Reliability	Chronbach $\alpha$
Person	.18	1.12	2.79	.89	.91
Item	.00	.62	4.68	.96	

### 3.2. Validity

Robust and valid measuring tools should only measure one concept and the variable that is completely unified, in other words it has a good and reliable unidimensionality value [17]. The unidimensionality condition will easily answer "does the tool really measure what should be measured?" Based on the data in Table 2, the fact that the raw measure item is at 41.7%, which means that the measuring instrument has been eligible to explain the condition of mathematical anxiety. Furthermore, the unexplainable condition of the measuring instrument does not exceed the value of 15%, either on the 1<sup>st</sup> contrast to the 5<sup>th</sup> contrast.

**Table 2.** The unidimensionality of MARS-E using standardized residual variance

	Empirical		Modeled	
Total raw variance in observations	36.0	100.0%		100.0%
Raw variance explained by measures	15.0	41.7%		41.8%
Raw variance explained by persons	6.6	18.3%		18.4%
Raw Variance explained by items	8.4	23.4%		23.5%
Raw unexplained variance (total)	21.0	58.3%	100.0%	58.2%
Unexplnd variance in 1st contrast	2.6	7.3%	12.6%	
Unexplnd variance in 2nd contrast	2.1	5.9%	10.1%	
Unexplnd variance in 3rd contrast	2.1	5.7%	9.8%	
Unexplnd variance in 4th contrast	1.7	4.6%	7.9%	
Unexplnd variance in 5th contrast	1.6	4.4%	7.6%	

In general, it can be interpreted that the tool has met the criteria as inventory to make an accurate and accurate estimate of students' anxiety about mathematics. It is based on inventory power analysis in explaining the condition of variables in a unified dimension.

### 3.3. Rating Scale Validity

An analysis of rating scale is done to see if respondents can understand well the response options given to the inventory. If there are items that the respondent lacks or items that cause doubt to be answered, then they should be corrected or eliminated if necessary.

**Table 3.** Summary of MARS-E Category Structure

Label	Score	Observed			Sample Expect	Infit MNSQ	Outfit MNSQ	Andrich Threshold	Category Measure
		Count	%	Avrge					
1	1	332	12	-1.31	-1.35	1.09	1.07	None	(-2.95)
2	2	981	37	-0.30	-0.21	.80	.75	-1.76	-.84
3	3	863	32	.64	.50	.71	.70	.27	.94
4	4	491	18	1.31	1.43	1.24	1.33	1.50	(2.77)

Note: Observed average is mean of measures in category. It is not a parameter estimate.

The values on the observer average and the Andrich threshold generally show an increase at each level, with no equal value for each answer option. This means that respondents can accurately distinguish between four choices of answers well.

### 3.4. Item Fit and Item Difficulties

The analysis of the fit items in the early stages is done by looking at whether there are items that are outlier in the measurement so that the need for editorial adjustment or improvement of items thoroughly [17]. This analysis begins by calculating the range of normal curves that are on 2 SD, so the measure logit should be at -1.24 or +1.24. The data exposure revealed that there is an item with a measure value that is above the elementary level, i.e. MAC4 with the item "I am anxious if the teacher gives multiplication duties". Follow-up on this item needs in-depth analysis, because the Standard Error measurement does not show any error symptoms with the value 0.16 and the value of Outfit MNSQ is at 0.77 logit (<1.5). However, the condition of the item resides on an item with an easy to answer, so the item needs upon simply by fixing the editorial sentences on the inventory.

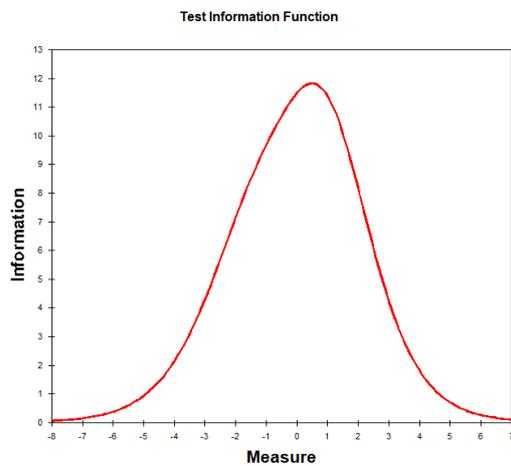
**Table 4.** Constructing Examinations from Calibrated Item, Item Difficulty, and Item Fit of the MARS-E

Item	Measure	Infit MNSQ	Outfit MNSQ	Perceived Difficulties
MAA10	1.00	1.14	1.08	<i>Most difficult item</i> ↑
MAC1	.69	1.23	1.28	
MAA3	.53	.79	.76	
MAA6	.53	1.26	1.29	
MAA4	.44	1.18	1.13	
MAA9	.44	.85	.82	
MAC2	.36	.81	.82	
MAA5	.25	.81	.79	
MAC6	.18	1.07	1.05	
MAC9	.15	1.14	1.16	
MAA1	.05	1.15	1.14	↓ <i>Cut point</i>
MAC8	.01	1.07	1.06	
MAC3	-.01	.95	.98	
MAA2	-.08	.85	.85	
MAA8	-.17	.84	.83	
MAC11	-.26	.94	1.00	
MAC5	-.35	.86	.84	
MAC7	-.40	1.09	1.21	
MAA7	-.46	1.03	1.00	
MAC10	-.85	1.08	1.05	
MAC4	-2.04	.85	.77	<i>Most easy item</i>

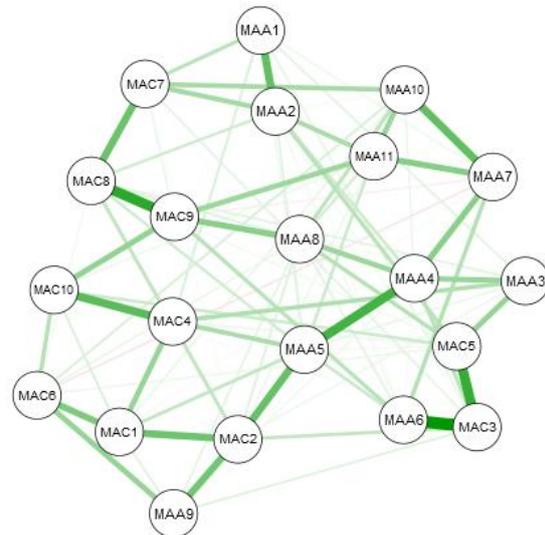
In general, the Outfit MNSQ (outlier-sensitive fit) value of inventory is between .50 - 1.50 logit. The fact of this data leads to the conclusion that no item is in a less productive state in the measurement process. Calibration of items in MARS-E Indonesia version is in good category, because the value of distortion in the measurement is in good level, which is not too predictable and really hard to predict and it make the item in an unstable condition. This leads to the conclusion that items in MARS-E are in strong inventory in estimating the students' mathematical anxiety conditions.

### 3.5. Test of Information Function

Analysis by using test of information function is used to see the level of exposure information and the ability of respondents in completing items on inventory [17]. Figure 1 explains that the value of information obtained from inventory is in the high category, which is at the level of 12 points of information. The level range of anxiety levels of mathematics measured by inventory is at the level of -6 to level 7, indicating that the range of anxiety levels that inventory can provide the information is in the high category.



**Figure 1.** Test Information Function of Students' Mathematics Anxiety



**Figure 2.** The network model structure interaction of MARS-E

However, based on Figure 1, it is well known that in general, the direction of the graph is likely to lead to the right, which means that in general inventory is more effective in estimating anxiety levels among respondents who are in anxious about mathematics. In other words, this inventory is also concluded to be very suitable given to subjects with middle to high ability, where the level of ability also has a significant relationship with student anxiety conditions. This explanation will be reinforced by the exposure to Figure 2.

### 3.6. Item Interaction

The interaction between items in the inventory can be seen through the network model estimation in Figure 2. Generally, the strength of the items is indicated by line strength on the network, where a weight line indicates a strong relation and a thin line indicates a weak relationship and if no lines indicate that there is no relationship between the items [18]. In contrast, the red line indicates that the item is against a negative relation (on the "R" value estimation, this indicates a negative correlation, the stronger the weight on the line the higher the value).

The network model estimation in Figure 2 shows the existence of very strong connectivity between MAA6 item (*I was worried when the math teacher called my name*), MAC3 (*I'm afraid I cannot estimate the size of a box*) and MAC5 (*I was worried about meeting a long math task*). The condition of the links between the three items indicates that there is anxiety that occurs to the student when their name is called by the teacher during the lesson and it is related to the work of the mathematical task (the estimated value of the network is presented in Open Science Framework, available in open source).

On the other hand, connectivity with a negative value (although the strength of the relation is in very low category) is indicated by the MAC9 item (*I was worried when my teacher noticed me doing class exercises*), MAA7 (*I'm worried if I remember tomorrow there's a math test*) and MAC6 (*I'm afraid I cannot do any form/geometric drawing assignment*). This shows that the three items on the inventory are contradictory, if the student is not anxious when performing the task in the class while the teacher is concerned, then generally they would not experience anxiety if remembers that there will be a math test, it also happens while working the task of geometry.

In general, there are no separate items from the groups in MARS-E. This indicates and supports the data exposure in Table 2 that all items in MARS-E are composite items and can support the process of measuring and estimating anxiety levels in mathematics subject.

#### 4. Conclusion

Based on the findings and exposure of research data, it can be concluded that MARS-E inventory adapted into the Indonesian version has fulfilled the requirements in terms of validity and reliability based on Rasch analysis and network psychometrics model in measuring students' anxiety level on mathematics learning. This inventory is believed to be able to measure well the anxiety conditions that are used in the process of analyzing the condition of the students in the process of diagnosis of learning difficulties. At the end, psychological conditions that disturb the students through the learning process of mathematics can be overcome quickly, accurately, effectively and efficiently.

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