



A Rasch-based regression analysis of predictive relationships among mathematics motivation constructs

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Abstract

Mathematics motivation refers to students' internal or external beliefs, values, emotions, and regulatory processes that drive their engagement and effort in learning mathematics. This study investigates the relationships among the constructs of mathematics motivation (intrinsic value, self-regulation, self-efficacy, utility value, and anxiety). The methodology of this research employs a quantitative approach (Rasch and partial t-test analyses), with 317 secondary school students in Jakarta, Indonesia, as respondents. The validation and reliability instruments were conducted using the Rasch model, and then the regression analysis and partial t-test analyses were used to examine predictive relationships among the motivational constructs. The results showed that self-efficacy is the most influential factor, significantly predicting intrinsic value, self-regulation, utility value, and anxiety test. Intrinsic value and utility value also contributed significantly to multiple motivational outcomes, while anxiety test was predicted by intrinsic value, self-efficacy, and utility value, but not by self-regulation. The findings provide theoretical evidence that self-efficacy functions as a central mechanism linking key dimensions of mathematics motivation, underscoring its important role in shaping students' motivational profiles in mathematics learning contexts.

Keywords: mathematics motivation; motivational constructs; Rasch-regression

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Introduction

Understanding and strengthening students' motivation in mathematics learning plays a crucial role for teachers and policymakers, as it significantly impacts students' performance in mathematics. Intrinsic motivation and academic performance have a connection because they underpin autonomous, self-directed behaviour, mutually reinforcing with each shaping and supporting the other over time (Garon-Carrier et al., 2016; Ryan & Deci, 2000). Motivated students tend to engage in learning activities, persevere in the face of challenges, and develop a deep understanding of mathematical principles. On the other hand, students who lack motivation may struggle to grasp mathematical concepts, show disengagement, and achieve lower academic outcomes (Hosseini-Mohand & Hosseini-Mohand, 2023; Xia et al., 2022).

According to the Mathematics Motivation Questionnaire (MMQ) (Fiorella et al., 2021) there are several motivation factors: intrinsic value, self-regulation, self-efficacy, utility value, and anxiety test. Intrinsic motivation is doing an activity because it is personally rewarding and interesting, while autonomy involves having a sense of control and choice in one's learning. Intrinsic motivation is conceptualized as the force that motivates individuals from the time they are born to carry out an activity with satisfaction attached to several separable consequences (Breva & Galindo, 2020; Ryan & Deci, 2000). This impulse from within a person is the desire to do something to achieve a goal. Self-efficacy in mathematics can be examined by presenting questions regarding how strongly students trust their problem-solving abilities or do well on the following exams. To assess students' mathematical self-efficacy expectations, ask them how confident they are in their abilities to address a problem effectively or achieve strong results on the next test. Mathematical self-concept involves one's confidence in successfully solving math issues and scoring well on the next exams (Schukajlow et al., 2017).

While motivation and achievement are strongly associated, this means that critically to conceptualize mathematical motivation as a complex psychological aspect rather than achievement as an academic consequence. Understanding the structure of mathematics motivation is essential for describing how various motivational components interact to enhance or hinder students' learning experiences. According to (Calvin Briggs et al., 2014; Christodoulou et al., 2024; Stevens et al., 2004) self-efficacy and intrinsic motivation both play key roles in students' mathematics performance. Previous research (Hidayatullah et al., 2024; Li et al., 2025) has constantly shown that higher self-efficacy increases intrinsic motivation, and that both constructs play an important role in shaping students' engagement and achievement in mathematics. However, much of the existing literature has examined these constructs either in isolation or in relation to achievement outcomes, rather than investigating their directional relationships within the motivational system itself. Prior research on the MMQ has mostly focused on validating the instrument or investigating correlations between motivation and success, with little attention given to directional predictive linkages across motivational dimensions using psychometrically calibrated measures. Few studies have used Rasch modeling to estimate interval-level latent traits before investigating structural links

between constructs. There is still a lack of understanding about how various structures of mathematical motivation interact and which are crucial to the motivational framework.

Furthermore, this study rigorously investigates the structural relationships among key constructs of mathematics motivation, which is guided by the following research questions: (1) Which motivational constructs are identified as the most influential drivers of students' motivation in mathematics learning? And (2) To what extent do the mathematics motivation constructs predict one another within an interconnected motivational system? Through these questions, the study aims to provide a more detailed understanding of how motivational aspects correlate to shape students' engagement and persistence in mathematics.

Methods

Participant and content

A survey-based design was implemented to examine the research question, and the Rasch model and regression analysis were conducted to analyze the contribution of each construct's variable. In this study, participants were collected by using a convenience sampling method. Convenience sampling is a non-probabilistic technique in which researchers select readily available and willing participants, commonly used when obtaining representative samples is constrained by limitations in time, resources, or accessibility (Wang, 2024). The targeted participants were students from the higher secondary school tenth and eleventh grades. The instrument used was a Google form and was given to respondents with the help of the class teacher, who distributed it to each class group. 317 respondents filled out the survey, which consisted of 140 students in tenth grade and 177 students in eleventh grade. There were 201 females and 116 males with an age range between 15 and 18 years old. Table 1 shows demographic information.

Table 1. Demography of the participants

Demography data	
Gender	Male (N=116) Female (N=201)
Age	15 – 16 years old (N=216) 17 – 18 years old (N=99)
Previous Education	Government school (N=251) Private school (N=64)
Grade	10 th (N = 140) 11 th (N = 177)

Data collecting instrument

The current study adopted Fiorella et al's (2021) questionnaire. Originally, Fiorella et al's (2021) questionnaire was the adapted version of (Glynn et al., 2009) that was originally developed to assess science in the form of the Science Motivation Questionnaire (SMQ). In the research of (Fiorella et al., 2021) The word science in SMQ was replaced by mathematics. In this current study, Fiorella et al's (2021) questionnaire was adopted and translated into the Indonesian Language to collect the data. In addition, the original questionnaire contains 20

items; however, there was an item that had the same meaning when translated into Indonesian, so only 19 items were used. Before the data-collecting process, the 19 items in the questionnaire were validated using the Rasch Model, and the evidence showed that all items in the instrument exhibited strong validity and reliability. Validity testing uses the Rasch model principle with the MNSQ criteria (0.5 to 1, t Measure Correlation (0.4 to 0.8) at least two criteria are required (Bond et al., 2020). The Mathematics Motivation Questionnaire (MMQ) uses a Likert scale to rate each of the 19 items on the survey. There are five constructs in the questionnaire on math students' motivation: intrinsic value, self-regulation, self-efficacy, utility value, and exam anxiety (Table 2).

Table 2. Mathematics motivation questionnaire (MMQ)

Variables Indicators	Definition of indicator	Total Item	Item Number
Intrinsic Value	Students' feelings about learning mathematics independently are important	3	1-3
Self-Regulation	The desire of students to engage in learning strategies	4	4-7
Self-efficacy	Students' belief that they possess the competence and abilities required to excel in learning mathematics	3	8-10
Utility value	The perception of students that mathematics is relevant to their future life and career	4	11-14
Anxiety test	The anxiety of students regarding personal assessment in mathematics compared to others	5	15-19

Data analysis

The data analysis in this research employed a quantitative technique, specifically the Rasch Model, assisted by Winsteps software. The following are the stages used in the data analysis: 1) Obtaining data from Google Forms that converted to an Excel file; 2) Coding the data according to the Rasch Model procedure; 3) Screening the data for outliers and missing values; 4) Conducting descriptive statistics for the variables and variable construct; 5) Investigating Differential Item Functioning (DIF) based on demographic data; 6) The data logit was computed into further analyses, which is regression analysis, using statistical software.

Results

Descriptive statistics

Based on person measures, data analysis revealed that 63 of the 317 respondents did not match the criterion or were a misfit. In Rasch analysis, misfitting items or persons are examined and, if necessary, removed because they violate the model's assumptions of unidimensionality and probabilistic response consistency, thereby threatening measurement validity and parameter invariance (Bond, Trevor G. & Fox, 2015; Linacre, 2025). Removing substantively unjustifiable misfit improves scale precision and ensures that the remaining items validly represent the intended latent construct. As a result, just 254 people satisfied the person fit requirements. The average of the individual measurements was 0.67, and the standard deviation

(SD) was 1.19. The person and item separations were also 2.67 and 2.88, respectively. The person and item reliability were 0.88 and 0.99, respectively, showing great consistency in respondents' answers and good quality of the instrument's items. Figure 1 shows a Wright Map analysis utilizing Winsteps to assess the ease and complexity of each item, as well as the respondents' ability to understand each item. The map indicated three levels: low, moderate, and high. Observing the person measure, the lowest-scoring respondents supplied the same response to all questionnaire items.

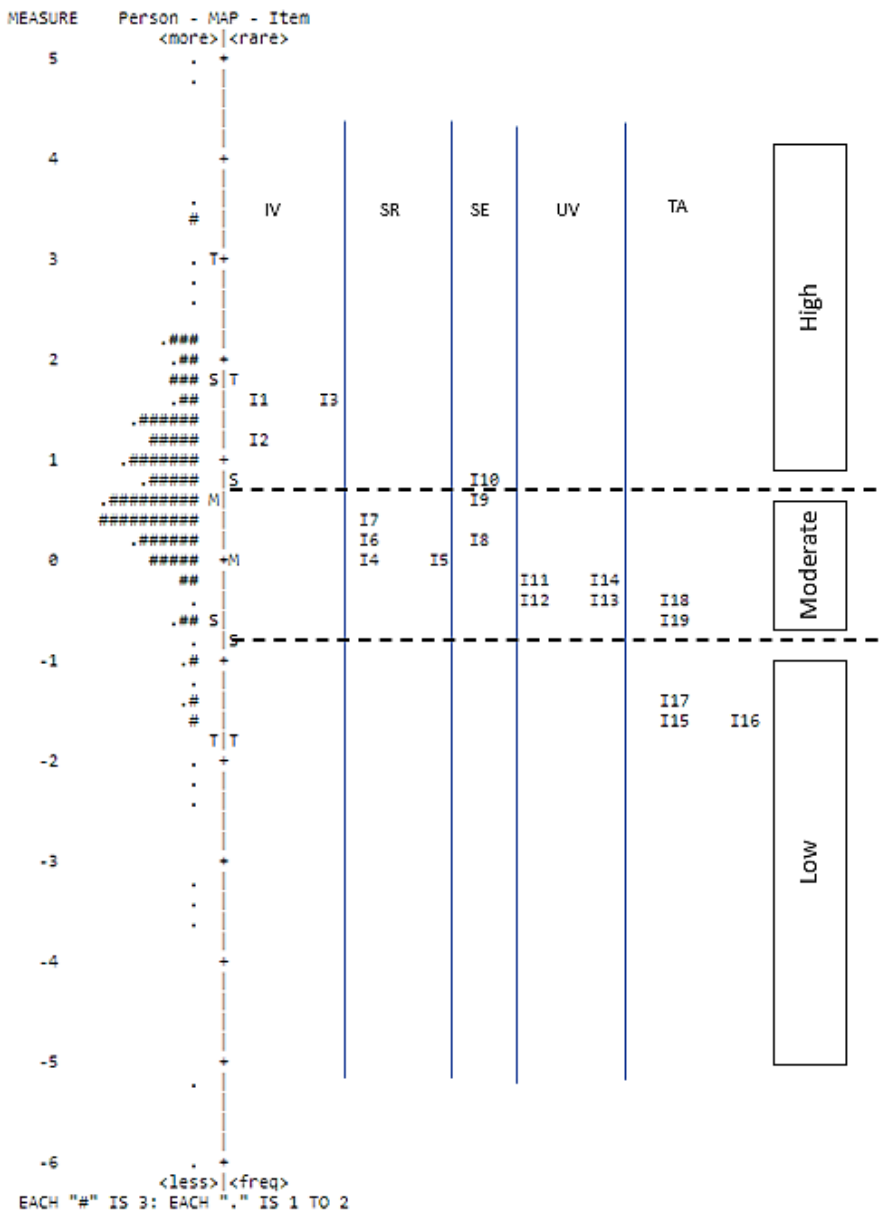


Figure 1. Wright person-item map (N=254) of the mathematics motivation questionnaire (MMQ)

Secondary school students' level of mathematics motivation

The analysis of Person-Differential Item Functioning (DIF) was run to examine differences in item responses based on demographic data. In this study, there are gender, age, grade, and

previous education level. The DIF analysis revealed difficulties in understanding items I2, I3, and I17, as shown in Table 3.

Table 3. DIF analysis by gender, age, grade, and the latest education

Item	Demography		DIF	DIF	t
			Measure	Contrast	
I2	Gender	Male	1.30	-0.43	2.08*
		Female	0.87	0.43	
I3	Gender	Male	1.78	-0.55	2.65**
		Female	1.23	0.55	
I17	Gender	Male	-1.55	0.64	2.70*
		Female	-0.92	-0.64	

*p value < .05, **p value < .01

Furthermore, an analysis for each variable construct was conducted to examine students' responses toward each indicator of mathematics motivation learning. Based on the testing using summary statistics in Winstep to evaluate how strongly the intrinsic value factor affects students' motivation in learning mathematics, as shown in Table 4, it was found that the person reliability for intrinsic value is 0.67 and the item reliability is 0.91. This indicates that the consistency of students' responses to the intrinsic value items is relatively adequate, while the quality of the items is considered good. The person reliability for each indicator suggests that respondents' consistency in answering each item is relatively satisfactory, whereas the item reliability for the self-efficacy and anxiety test is good. The lowest item reliability is observed in the utility value construct, while self-regulation is considered moderately reliable. Based on the analysis of Person-Differential Item Functioning (DIF), there were no differences observed in terms of gender, age, grade, and previous education for intrinsic value, self-regulation, self-efficacy, and utility value.

Table 4. Person and item reliability of indicators

Indicators	Person Reliability	Item Reliability
Intrinsic value (IV)	0.67	0.91
Self-regulation (SR)	0.60	0.75
Self-efficacy (SE)	0.64	0.92
Utility Value (UV)	0.66	0.72
Anxiety Test (TA)	0.62	0.96

Additionally, a linear regression analysis was executed to examine the partial relationships among learning mathematics motivation constructs. In the linear regression analysis, logit data were used for each construct variable. The results of the determinant coefficients of the independent construct variables towards the dependent construct variable are shown in Table 5.

Table 5. Results of the determinant coefficient

Independent Variable	Dependent Variable	Multiple R	R Square	Adjusted R
Self-Regulation Self-Efficacy Utility Value	Intrinsic Value	0.965	0.931	0.930

Independent Variable	Dependent Variable	Multiple R	R Square	Adjusted R
Intrinsic Value Self-Efficacy Utility Value	Self-Regulation	0.977	0.954	0.953
Intrinsic Value Self-Regulation Utility Value Anxiety Test	Self-Efficacy	0.979	0.959	0.958
Intrinsic Value Self-Regulation Self-Efficacy Anxiety Test	Utility Value	0.980	0.960	0.959
Intrinsic Value Self-Efficacy Utility Value	Anxiety Test	0.972	0.944	0.943

Based on Table 5, it can be observed that the R-squared coefficient for intrinsic value is 0.931, indicating that intrinsic value is influenced by self-regulation, self-efficacy, utility value, and anxiety test variables to the extent of 93.1%. Self-regulation is influenced by intrinsic value, self-efficacy, and utility value, with an R-squared value of 95.5%. The R-squared value of 0.959 for self-efficacy indicates that intrinsic value, self-regulation, utility value, and anxiety test collectively account for 95.9% of the variation in self-efficacy. Regarding the utility value construct, it is influenced by intrinsic value, self-regulation, self-efficacy, and anxiety at a magnitude of 96%, whereas anxiety value is influenced by intrinsic value, self-efficacy, and utility value with an R-squared value of 94.4%. These aspects include intrinsic motivations such as personal interest and enjoyment of the task, to extrinsic drivers like rewards and social recognition. Self-efficacy expectations positively impact students' motivation and performance. In addition, the result of the F-test that figures out the connection among construct variables is illustrated in Table 6.

Table 6. Summary F-test

Independent Variable	Dependent Variable	Regression	
		F	Sign. F
Self-Regulation Self-Efficacy Utility Value	Intrinsic Value	834.940	.000
Intrinsic Value Self-Efficacy Utility Value	Self-Regulation	1296.340	.000
Intrinsic Value Self-Regulation Utility Value Anxiety Test	Self-Efficacy	1440.669	.000
Intrinsic Value Self-Regulation Self-Efficacy Anxiety Test	Utility Value	1483.608	.000

Independent Variable	Dependent Variable	Regression	
		F	Sig. F
Intrinsic Value Self-Efficacy Utility Value	Anxiety Test	1046.754	.000

Furthermore, the outcomes of the t-test and the significance values (<0.05) indicate which variables influence each other. Intrinsic value, self-efficacy, and utility value are influenced by the other four construct variables with a significance level of < 0.05. On the other hand, self-regulation is only influenced by intrinsic value, self-efficacy, and utility value. Similarly, the anxiety test is influenced by intrinsic value, self-efficacy, and utility value.

Table 7. Results of partial t-test

Independent Variable	Dependent Variable	t	Sig.
Self-Regulation	Intrinsic Value	2.093	.037
Self-Efficacy		6.307	.000
Utility Value		2.021	.044
Anxiety Test		2.416	.016
Intrinsic Value	Self-Regulation	2.093	.037
Self-Efficacy		6.113	.000
Utility Value		7.195	.000
Anxiety Test		1.054	.293
Intrinsic Value	Self-Efficacy	6.307	.000
Self-Regulation		6.113	.000
Utility Value		2.513	.013
Anxiety Test		3.913	.000
Intrinsic Value	Utility Value	2.021	.044
Self-Regulation		7.195	.000
Self-Efficacy		2.513	.013
Anxiety Test		7.273	.000
Intrinsic Value	Anxiety Test	2.416	.016
Self-Regulation		1.054	.293
Self-Efficacy		3.913	.000
Utility Value		7.273	.000

Discussion

This study examined the interrelationships among five constructs of mathematics motivation— intrinsic value, self-regulation, self-efficacy, utility value, and anxiety test—among secondary school students. Using the Rasch model and regression analysis, the study revealed that these motivational aspects are highly linked and mutually influential, revealing the complex and dynamic nature of students' readiness to learn mathematics.

Interrelationships among motivational constructs

The five motivation elements were found to be strongly associated and predictable in multiple regression analysis. Indicating a high degree of interdependence among students' motivational systems.

1. Intrinsic Value

The model for intrinsic value showed that it is significantly influenced by self-regulation, self-efficacy, utility value, and anxiety test. Intrinsic value has consistently been shown to positively relate to the practice of learning strategies, self-regulation, and academic performance, with highly intrinsically motivated students demonstrating stronger cognitive engagement and more effective learning strategies, while its direct effect on achievement may be modest but remains a powerful mediator of self-regulation and cognitive involvement (El-Adl & Alkharusi, 2020; Stavropoulou et al., 2025).

2. Self-Regulation

In terms of self-regulation, intrinsic value, self-efficacy, and utility value showed strong predictive associations. Students who can regulate themselves tend to demonstrate higher intrinsic value and self-efficacy, as well as better academic achievement, and self-regulation is also negatively associated with anxiety test (Saaidin et al., 2023). The significant link between self-regulation and intrinsic value also supports the notion that students who find learning mathematics enjoyable are more inclined to organize, oversee, and assess their own learning activities (Schunk & DiBenedetto, 2020). Moreover, students' belief that mathematics has practical value (utility value) motivates them to persist and self-regulate their effort even in challenging tasks (Eccles & Wigfield, 2020).

3. Self-Efficacy

Self-efficacy is strongly influenced by intrinsic worth, self-regulation, and utilitarian value. This illustrates that students' personal interests and ability to handle learning processes have a significant impact on their confidence in mathematics. Prior research shows that self-efficacy is positively aligned with academic performance and self-regulation, acts as a mediator between motivation and performance, and reliably decreases anxiety test (Niaz & Mukhtar, 2025). This means that motivation and self-efficacy and the construct mutually enhance one another.

Students who exhibit higher self-efficacy are more driven, which leads to more diligence and perseverance when faced with problems that can be considered when examining motivation (Bandura, 1986; Rheinberg et al., 2002). Therefore, enhancing students' confidence requires instructional approaches that build both competence and value in learning mathematics.

4. Utility Value

Utility value shows that it is highly influenced by all other motivational dimensions. This supports (Eccles & Wigfield, 2020) This holds that students' engagement is motivated by their ideas about the utility of a subject for future aspirations. The substantial predictive impacts of intrinsic value and self-efficacy indicate that students who enjoy mathematics and believe they can succeed are more likely to see it as beneficial to their academic and career goals. Utility value also influences motivation and learning strategies, albeit its impact on academic accomplishment is not always considerable, especially among younger students, and it is more important in encouraging persistence and long-term interest (Üner et al., 2020).

5. Anxiety test

Anxiety test exhibited a strong statistical relationship with intrinsic value, self-efficacy, and utility value, demonstrating that emotional factors are linked to motivational beliefs. Anxiety test has consistently been linked to lower academic achievement; students who have high levels of anxiety test have lower self-efficacy and self-regulation, as well as poorer performance, though intrinsic motivation may mitigate the negative effects of anxiety test (Niaz & Mukhtar, 2025; Santi et al., 2024). This study demonstrated a negative link between self-efficacy and anxiety test, which is consistent with the findings of (Mcmullan et al., 2012), who discovered that students with higher self-efficacy reported reduced anxiety and better mathematical performance. The findings indicate that regulating students' emotional responses is critical for establishing a balanced motivational profile.

Overall, the data show that the five motivation structures work together as a reciprocal and dynamic system, rather than as independent variables. This link is consistent with the social-cognitive theory of motivation (Cleary & Kitsantas, 2017; Fiorella et al., 2021), which emphasizes reciprocal causality between personal, behavioral, and environmental factors. The high predictive values among constructs indicate that mathematics motivation is a network of reinforcing beliefs, with gains in one area (e.g., self-efficacy) enhancing others (e.g., self-regulation and intrinsic value).

Conclusion

This study examined the five constructs of the Mathematics Motivation Questionnaire, providing empirical evidence that mathematics motivation operates as an integrated system rather than as a collection of discrete components. Self-efficacy played a pivotal role among all constructs, highlighting its importance in enhancing students' motivation in mathematical learning environments. These findings augment theoretical frameworks by endorsing a comprehensive perspective of mathematics motivation, wherein cognitive, affective, and self-regulatory factors are intricately interconnected.

However, some problems still need to be acknowledged. First, the sample was conducted using participants from one school. Second, the cross-sectional design limits causal interpretations and does not consider changes in motivating factors over time. Subsequent research should address these limitations by investigating the developmental and reciprocal aspects of mathematics motivation through longitudinal methodologies. Additionally, structural equation modeling is advocated for the examination of intricate models, including mediating and reciprocating relationships among constructs, to attain a comprehensive understanding of the dynamic mechanisms that underpin students' mathematical motivation.

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Declarations

- Conflicts of Interest : The authors declare no conflict of interest.
- Generative AI Statement : No Generative AI Used:
AI Used for Limited, Non-Substantive Support:
A generative AI tool, such as Grammarly, was employed solely for language editing and minor phrasing enhancements. All conceptualization, analysis, and scholarly content were independently developed and verified by the authors.
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- Author Contributions : **Fitri Alyani:** Develop, collect, and analyze data and manuscript; **Nurafni:** Instrument validation, advising, revising the manuscript; **Windia Hadi:** Instrument validation, advising, revising the manuscript.

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Appendix

No.	Indicators	Statements
1	Intrinsic value	Saya senang belajar matematika.
2		Saya merasa belajar matematika itu menarik.
3		Saya suka matematika yang menantang bagi saya.
4	Self-regulation	Jika saya mengalami kesulitan dalam belajar matematika, saya mencoba mencari penyebabnya.
5		Saya berusaha keras dalam belajar matematika.
6		Saya menggunakan strategi untuk memastikan saya belajar matematika dengan baik.
7		Saya mempersiapkan diri dengan baik untuk tes dan kuis matematika.
8	Self-efficacy	Saya yakin saya akan mengerjakan tugas dan proyek matematika dengan baik.
9		Saya yakin saya dapat menguasai pengetahuan dan keterampilan dalam mata pelajaran matematika.
10		Saya yakin bisa mendapatkan nilai 100 dalam mata pelajaran matematika.
11	Utility value	Saya berpikir tentang bagaimana belajar matematika dapat membantu saya lulus seleksi perguruan tinggi.
12		Saya memikirkan bagaimana pelajaran matematika yang saya pelajari akan berguna bagi saya.
13		Saya berpikir tentang bagaimana belajar matematika dapat membantu saya di masa depan.
14		Saya memikirkan bagaimana saya akan menggunakan matematika yang telah dipelajari.
15	Anxiety test	Saya merasa gugup saat akan mengerjakan tes matematika.
16		Saya menjadi cemas ketika tiba waktunya untuk mengikuti tes matematika.
17		Saya khawatir akan gagal dalam tes matematika.
18		Saya khawatir jika siswa lain lebih baik dalam matematika.
19		Saya berpikir tentang bagaimana nilai matematika saya akan mempengaruhi nilai saya secara keseluruhan.