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The students' mathematics motivation scale: a measure of intrinsic, extrinsic, and perceptions of mathematics

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A B S T R A C T
Students' mathematical motivation is an important factor in understanding mathematics. Many studies have shown that students who have high motivation to learn mathematics, get better achievement than students who have low motivation. However, research that provides instruments to measure the mathematics motivation scale is still rare. This research aims to: (1) Describe the process of developing the Student Mathematics Motivation Scale (SMMS) instrument, (2) Describe the results of developing the Student Mathematics Motivation Scale (SMMS) instrument. This research model uses survey research with mixed methods. The research subjects were Junior High School students in MTs. 2 Nurul Islam, Mojokerto, Indonesia. This research produced 19 questions containing 3 main indicators, they are intrinsic goals, extrinsic goals, and perceptions of mathematics. The validity test results show a very good level of validity, as well as a high category of reliability ($\alpha = 0.817$). Therefore, this instrument is very good for measuring students' mathematics motivation scale.

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1. INTRODUCTION

Learning mathematics has many challenges. Low mathematics achievement is the main problem experienced by most students worldwide. The factors that influence the achievement are in the form of factors within students (internal) and factors from outside students (external) (Papanastasiou, 2000; Aspelin, 2012; Fitrianti & Nur, 2018). According to Slameto (2010), internal factors are grouped into physiological factors such as health and body condition; and psychological factors such as attention, interest, talent and readiness, while external factors, they are school factors such as curriculum, teaching methods, relations between school members, discipline at school, learning tools, condition of buildings and libraries. Several attempts have been made to solve this problem. One of the most important psychological concepts in the world of education is motivation (Valerand, et al, 1992). Many studies have empirically proven that motivation to learn mathematics can predict student learning achievement in mathematics. Motivation has a big influence on achievement (Herges, Duffield, Martin, & Wageman, 2017; Cleary & Chen, 2009; Yunus & Ali, 2009; Michaelides, Brown, Eklöf, & Papanastasiou, 2019). Therefore, the relationship between motivation and academic achievement can't be

underestimated (Zakaria & Massimiliano, 2021).

Measuring tools for students' mathematics motivation are needed to predict achievement results in mathematics (Zakaria & Massimiliano, 2021). There are many theories and research that examine tools for measuring student motivation. One theory that is often used is the theory from Decy & Ryan (1985, 1991) which suggests 3 main components to describe motivation. These three components include intrinsic motivation, extrinsic motivation, and amotivation. This theory became the basis for much subsequent research. Pintrich (1992) created a guidebook on learning questionnaires. The book contains studies on motivational questionnaires and learning strategies. Motivation has three value components, namely intrinsic goals, extrinsic goals, and task value. There are a total of 12 statements given in the book, and they are spread into 4 statements for each component. Vallerand et al (1992) created an instrument to measure academic motivation which is generally used by various researchers in many countries and many types of educational research. The instrument developed by Valerand consists of 28 statements and is divided into 7 sub-indicators, including 3 intrinsic motivations (intrinsic motivation to achieve something, intrinsic motivation to know, and intrinsic motivation to experience stimulation), 3 extrinsic motivations (introjected, external, and applicable rules), and amotivation.

Researchers are interested in conducting researching and developing a student mathematics motivation scale (SMMS). Teachers, curriculum developers, policymakers, and other educational stakeholders will get benefit from this research. They can use it to improve student achievement in mathematics. This study is only the beginning of an ongoing study of student motivation and its relationship to other personal factors. There are several problem formulations used in this research: (1) How is the process of developing the Student Mathematics Motivation Scale (SMMS)? (2) What are the results of developing the Student Mathematics Motivation Scale (SMMS)?

2. METHOD

Based on the research questions, this research is classified as development research and uses mixed analysis methods. The quantitative method is used to analyze data in the form of scores from validation results, as well as scores from questionnaire tool results. The qualitative method is used to analyze data in the form of notes, suggestions, and comments from validators who validate the questionnaire tools.

The sampling method uses non-probability sampling techniques. The selection of sampling units is based on subjective considerations or assessments and not on the use of probability theory (Siregar, 2012). There are 526 students spread across classes VII and VIII, but there are still no class IX students. The samples taken were only class VIII students. This is based on the researcher's opinion that they have been studying at the Junior High School level for longer, so their learning experience and level of motivation are more clearly visible. Class VIII consists of 11 classes, which are A, B, C, D, E, F, G, H, I, J, and K. There are 106 students spread across several classes used as samples. The classes we use are B, C, D, G, I, J, and K. The following table 1 contains the distribution of the number of students used as research samples.

Table1. The number of students used as research samples

Class	Total of students
B	15

C	19
D	13
G	14
I	14
J	16
K	15
Total	106

Research instruments are used as a tool to collect data from research. The instruments consisted of a validation sheet and a Student Mathematics Motivation Scale Questionnaire. Details of the instruments used can be seen in the table 2.

Table 2. The research instruments

Instruments	Observed data	Respondents
Validation's sheets	Validation of Student Mathematics Motivation Scale (SMMS)	Lecture and Teacher
Student Mathematics Motivation Scale (SMMS)	Intrinsic	Students
	Extrinsic	
	Perception about Mathematics	

The validation sheets instrument is used to measure the level of validity of the SMMS questionnaire. Several criteria analyzed in instrument validity, are content, constructive, and language. In this case, the content validity is used to measure the extent of conformity between each statement and the purpose of making the questionnaire. Constructive validity is used to measure the technicalities of preparing questionnaires related to instructions for filling out questionnaires and formulating questionnaire statement items. Language validity is used to examine the accuracy and effectiveness of the sentence formulation in each statement. This validation sheet was given to practitioners and experts, they are Mathematics teachers at MTs. 2 Nurul Islam and Mathematics Lecturer at STAI Nurul Islam. The questionnaire instrument for measuring students' mathematics motivation scale is structured based on indicators, namely intrinsic, extrinsic, and perceptions about mathematics.

3. RESULTS AND DISCUSSION

3.1 The Developing Process of Student Mathematics Motivation Scale (SMMS)

The instrument development model uses three phases, namely preliminary research, prototype phase, and assessment phase (Nurkarim, et al., 2022). The activities implemented at each phase of instrument development and the results obtained at each phase are described as follows:

3.1.1 Preliminary Researches

In this phase, the researcher made observations of the Mathematics learning process that was being implemented at MTs. 2 Nurul Islam. Based on observations, it was found that several students who fell asleep in class, and many students were not focused on learning. This indicates that they were not enthusiastic about learning Mathematics.

Researchers held discussions with several mathematics subject teachers in classes VII and VIII MTs. 2 Nurul Islam, and it was concluded that student's motivation to study mathematics was very low. The conclusions drawn were still only initial assumptions that needed further research.

Based on that, it was necessary to create an instrument that was able to measure student's level of motivation to learn mathematics. This instrument is used as evaluation material in designing further mathematics learning.

3.1.2 Prototype Phase

At this phase, an instrument was designed that fits with the theoretical studies and preliminary research. Mathematics motivation in this research is described into 3 main indicators, they were intrinsic, extrinsic, and perceptions about mathematics. Intrinsic is related to the extent to which students see themselves participating in tasks for reasons such as challenge, curiosity, and mastery of the subject (Pitrinch, et al, 1991). Intrinsic motivation describes a situation where an individual is involved in an activity for the sake of the activity itself, the pleasure obtained from it, and the satisfaction obtained from participating in the activity (Zakaria & Massimiliano, 2021). Having an intrinsic orientation towards academic tasks shows that students' participation in the subject comes from themselves, not from the intention to achieve other goals.

Pitrinch et al (1991) also explained about extrinsic. Extrinsic is not directly related to participation in the task itself (such as grades, awards, or comparing scores with other people). Meanwhile, the final indicator is perceptions about mathematics. It was described into several statements whose ultimate goal refers to the reasons why students participate in mathematics subjects ("Why am I doing this?"). The results of this phase are described in the form of the SMMS instrument in Table 3.

Table 3. The students' mathematics motivation scale

Indicators	Questionnaire	Item Number		Total of item
		Positif statements	Negative statements	
Intrinsic	I like Mathematics because it challenges me, so I can learn new things	2		9
	I didn't study mathematics of my own free will		3	
	The most satisfying thing for me in Mathematics is trying to understand the content as accurately as possible	9		
	I didn't study Mathematics material before it was given to me by a teacher at school		6	
	I will take additional Mathematics lessons (courses) even though it doesn't guarantee I will achieve good achievement	8		
	When I have free time, I look at Mathematics questions from previously studied material, and work on these questions	10		
	I will not do mathematics questions if the teacher doesn't ask me to do them		11	

	Mathematics material is so boring that I prefer to draw, doodle or daydream while learning is going on.		7	
	Getting good achievement in Mathematics is the most satisfying thing for me	1		
Extrinsic	I want to learn Mathematics so that I can teach friends or other people who want to learn it.	5		5
	I want to achieve good achievement in Mathematics because it is important to show my abilities to family, friends, or other people.	12		
	I wouldn't be enthusiastic about studying Mathematics if my parents and teachers didn't give me gifts		13	
	I thought I couldn't use what I learned in this Mathematics subject in other subjects.		14	
	It is not important for me to study Mathematics in this class.		4	
Perception about Mathematics	I am not interested in the materials in Mathematics learning		15	6
	I think every material in this Mathematics subject is useful for me to learn	17		
	I think studying Mathematics is very important because this subject makes my mind develop	20		
	I am confident that I can understand the basic material in Mathematics	19		
	I am not sure that I can understand the difficult material that the teacher has explained		18	
	I am not enthusiastic about studying mathematics because it has nothing to do with my dreams		16	

Based on Table 3, there are a total of 20 statements made from these indicators and they are divided into 11 positive statements and 9 negative statements. Intrinsic indicators are translated into 9 statement items consisting of 5 positive statements and 4 negative statements. Extrinsic indicators are translated into 5 statements consisting of 2 positive statements and 3 negative statements. The final indicator's is students perceptions about mathematics, which are described in 6 statements and consist of 3 positive statements and 3 negative statements. The instrument used is the Likert Scale with 5 assessment categories, namely Strongly Agree (scored 5), Agree (scored 4), Undecided (scored 3), Disagree (scored 2), and Strongly Disagree (scored 1). If the score obtained is high, this shows that the students' motivation to learn mathematics is at a high

level, and vice versa.

3.1.3 Assessment Phase

In this phase, the SMMS Questionnaire was given to the validator for validation. Table 4 contains the results of the questionnaire validation.

Table 4. The results of the questionnaire validation

No	Validity criteria	Score	
		Validator 1	Validator 2
I	Content Validity		
	1. The content of the material is in accordance with the measurement objectives	4	4
	2. The content of the material is a statement	4	4
	3. The content of the material plays a role in knowing student motivation	4	4
II	Construct Validity		
	1. There are clear instructions on how to answer	4	4
	2. The main points of the questions are formulated clearly	4	4
III	Language Validity		
	1. The sentence structure is very communicative	4	3
	2. Using language that is in accordance with good and correct Indonesian language rules	4	4
	3. The language used does not give rise to multiple interpretations		
	4. Using language that is easy for students to understand	3	3
	5. The statement doesn't contain issues regarding ethnicity, religion, race or inter-group relations	4	4
		4	4

The questionnaire validation used is a Likert Scale with 4 assessment categories, namely Strongly Valid (scored 4), Valid (scored 3), Invalid (scored 2), and Strongly Invalid (scored 1). Based on Table 4, it can be seen that the score from each validator for each aspect is at least good, so it meets the valid criteria. The general assessment regarding this questionnaire is that it can be used without revision. In terms of content validity, the validator assesses that the instrument used is very good. This indicates that the questionnaire was created for the purpose for which it was created, namely measuring students' mathematics motivation. Constructive validity also received excellent marks from both validators. This means that there are clear instructions for filling in, and the statement items are clearly formulated. In terms of language validity, in general, it received an assessment with very good criteria, it's just that there were statements that were assessed by the validator as having double statements, but they were still acceptable because the validator's assessment was still in the good category. Next, the validation questionnaire results were used in the research.

3.2 The Results of Developing the Student Mathematics Motivation Scale (SMMS)

The SMMS questionnaire instrument was given to the research sample. The questionnaire results were analyzed using product moment correlation techniques with a significance level of 5%. Then,

the results were compared with the correlation table using n = 106 (r_{table} = 0.1909). If $r_{count} > r_{table}$, the statement item is valid and it can be used for the next process. Table 5 regarding the validity results using product moment Pearson Correlation statistics.

Table 5. The validity of test item using Pearson correlation

Indicator	Item	Pearson Correlation (r)
Intrinsic	IN 1	.301**
	IN 2	.569**
	IN 3	.491**
	IN 6	.181**
	IN 7	.659**
	IN 8	.312**
	IN 9	.602**
	IN 10	.400**
	IN 11	.285**
Extrinsic	EX 4	.568**
	EX 5	.442**
	EX 12	.380**
	EX 13	.521**
	EX 14	.482**
Perception about Mathematics	PM 15	.617**
	PM 16	.593**
	PM 17	.422**
	PM 18	.276**
	PM 19	.602**
	PM 20	.615**

Based on Table 5 above, it can be seen that of the 20 statements given, there is 1 statement whose value is rcount < rtable. This statement is statement number 6 which reads "I didn't study Mathematics material before it was given to me by a teacher at school". The statement does not meet the requirements so the statement is invalid.

Invalid statements were deleted and not analyzed further. In the next stage, there were a total of 19 statements that were categorized as valid to be tested for reliability using Cronbach's Alpha analysis. There are many differences of opinion among researchers regarding the results of Cronbach's Alpha analysis and whether the instrument category is said to be reliable or not. Hinton (2014) provides an alternative in providing an interpretation of the Cronbach's Alpha results in Table 6 below.

Table 6. Interpretation of alpha cronbach

Alpha Cronbach	Interpretation
$\alpha \geq 0{,}90$	Excellent Reliability
$0{,}70 \leq \alpha < 0{,}90$	High Reliability
$0{,}50 \leq \alpha < 0{,}70$	Moderate Reliability
$\alpha < 0{,}50$	Low Reliability

A statement item is said to have very high reliability if the Cronbach Alpha coefficient is equal

to or more than 0.90. It is said that reliability is high if it is in the score range of 0.70 and 0.90. It is said that the reliability is moderate if the coefficient is in the range of 0.5 and 0.70. Furthermore, a reliability coefficient below 0.50 is said to have low reliability. The following is Table 7 regarding the results of Cronbach's Alpha calculation.

Tabel 7. The coeffisient of cronbach's alpha

Indicator	Mean	Variant	Standard Deviation	Total Item	Cronbach's Alpha
Mathematics motivational scale	3,348	1,340	1,156	19	0,817
Intrinsic goal	3,207	1,411	1,186	8	0,618
Extrinsic goal	3,728	1,298	1,136	5	0,563
Mathematical perception	3,335	1,308	1,143	6	0,665

Based on Table 7 above, it can be seen that the Cronbach's Alpha calculation results for the entire questionnaire consisting of 19 statements reached 0.817, which means that the mathematics motivation scale questionnaire that has been prepared as a whole has high reliability. In more detail, we can observe that each subcategory, including intrinsic goals, extrinsic goals, and perceptions of Mathematics, received scores of 0.618, 0.563, and 0.665 respectively, which means that each subcategory is separately in the reliable category.

4. CONCLUSION

Motivation has been a major issue that has long existed in the world of education. It's just that not many instruments have been developed specifically to measure students' mathematics learning motivation. This research developed the Student Mathematics Motivation Scale (SMMS) instrument which consists of 3 main indicators of mathematics motivation, including intrinsic goals, extrinsic goals, and perceptions of mathematics. The SMMS contains 19 statements spread across each indicator, namely 8 statements of intrinsic goals, 5 statements of extrinsic goals, and 6 statements of perceptions of mathematics.

The SMMS was validated by mathematics lecturers and teachers and it was concluded that the SMMS validity level was in the very valid category. Trial testing on the research sample resulted in 19 valid statements, as well as 1 invalid statement out of a total of 20 statements. A valid statement obtained by calculating the Cronbach Alpha coefficient. After calculating the Cronbach's Alpha coefficient, the Cronbach's Alpha coefficient from SMMS was 0.817. The interpretation of the Cronbach Alpha coefficient which is 0.817 is that the level of reliability is high. Based that, it can be concluded that the SMMS questionnaire which consists of 19 statements is said to be valid and reliable. This means that the questionnaire can be used to examine students' level of motivation in mathematics subjects.

This SMMS can also be utilized by stakeholders in the education sector who directly develop mathematics learning, whether in primary, secondary or high level of schools. This instrument can also be adapted to various needs in the fields of education, psychology and other research fields. Even though the level of validity and reliability of the SMMS is high, in-depth research and theoretical studies to develop indicators of the growth of motivation must also continue to be developed, so that instruments for measuring motivation get even better.

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