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The Effect of Mathematics Anxiety and Intelligence on Students' Logical Thinking Ability

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Abstract. This study aims to determine the effect of mathematics anxiety and intelligence on students' logical thinking skills. Which involved 96 respondents at high school. The research instruments used in this study were mathematics anxiety questionnaires, intelligence test questions, and logical thinking ability test questions. The data analysis technique used is multiple linear regression analysis. The results of this study indicate that there is an effect of mathematics anxiety and intelligence on students' logical thinking abilities.

Keywords: Mathematics Anxiety; Intelligence; Logical Thinking Skill

Abstrak. Tujuan penelitian ini untuk mengetahui besaran pengaruh mathematics anxiety dan intelligence terhadap kemampuan berpikir logis peserta didik. Yang melibatkan 96 responden pada sekolah menengah. Instrumen penelitian yang digunakan dalam penelitian ini adalah angket mathematis anxiety, soal tes intelligence dan soal tes kemampuan berpikir logis. Analisis data menggunakan regresi linear berganda. Hasil penelitian menunjukkan bahwa terdapat pengaruh mathematics anxiety dan intelligence terhadap kemampuan berpikir logis peserta didik.

Kata kunci: *Mathematics Anxiety; Intelligence;* Kemampuan Berpikir Logis

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INTRODUCTION

Mathematics has a very important position in human life and in improving the progress of a nation. Because mathematics is part of the curriculum of education given to all students with the aim of training logical, critical, analytical, systematic, and creative thinking skills as well as training cognitive abilities (Zarch & Kadivar, 2006). In learning mathematics, students are not only taught how to count but by learning mathematics students will be able to improve their logical, analytical and systematic thinking skills and be able to apply them in everyday life, so that problems in mathematics can be solved (Putra et al., 2019; Sevgi & Arslan, 2020). To solve problems in mathematics, reasoning that involves logic is needed, such as the ability to think logically. The ability to think logically is the ability to think that uses logic to solve a problem or think about an event that may occur or the reality that occurs (Koray & Köksal, 2009).

Logical thinking is defined as the process of reaching conclusions using consistent reasoning (Sumarmo et al., 2012). Meanwhile, Sumarmo in (Octaria, 2017) aid that logical thinking includes logical reasoning activities and other mathematical activities such as understanding connections, communication, and solving problems logically. Tobin dan Capie (1981) concerning Piaget's theory of children's intellectual cognitive development, assessing students' logical thinking skills using the Test of Logical Thinking (TOLT) which includes five components, namely reasoning proportional, variable, probability, correlational, and combinatorial (Aminah et al., 2018).

Based on the explanation above, it can be concluded that the ability to think logically mathematically is thinking according to certain patterns or rules in making decisions, drawing conclusions, and solving problems related to mathematical problems and logical principles. If students have good logical thinking skills, students will be able to solve problems in mathematics well, and vice versa. To measure the logical thinking ability of these students, there are several indicators, including: (a) Able to draw analogy conclusions, generalizations, and compose conjectures; (b) Draw logical conclusions based on the rules of inference, check the validity of arguments, and construct valid arguments; (c) Develop direct, indirect and by mathematical induction proofs. (Septiati, 2016).

The low ability of students' logical thinking can be caused by one of the internal factors from within students who already have a negative view of mathematics such as assuming that mathematics is a difficult subject, causing anxiety when learning mathematics (Surya, 2017). In addition, there are also psychological factors in the form of negative attitudes from within students towards learning mathematics, which is characterized by feelings of anxiety, heart palpitations, anxiety, worry, and feeling unable to solve mathematical problems (Sukendra, 2018). When viewed from the symptoms experienced by students, this negative attitude is commonly referred to as mathematical anxiety, because one of the components in the indicators of mathematical anxiety is somatic and attitude.

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Somatic is related to changes in the state of the body, while attitude is an attitude that appears when someone has math anxiety (Santri, 2017). Excessive anxiety can disrupt the psychology of students when learning mathematics, of course, the mindset of students will also be disturbed (Suinn & Edwards, 1982).

Mathematics anxiety is a condition that involves feelings of tension, anxiety, and worry that can interfere with the concentration of students in learning mathematics (Richardson & Suinn, 1972). Ashcraft dan Faust mendefinisikan kecemasan matematika sebagai perasaan tegang, ketidakberdayaan, disorganisasi mental dan ketakutan yang dimiliki seseorang ketika diminta untuk memanipulasi angka, bentuk dan pemecahan masalah matematika define math anxiety as feelings of tension, helplessness, mental disorganization, and fear that a person has when asked to manipulate numbers, shapes, and solve mathematical problems (Zakaria & Nordin, 2008). Signs experienced when a person feels math anxiety are heartbeats faster, restlessness, increased anxiety, a strong desire not to take math lessons, and not believing in one's own ability to solve math problems (Hembree, 2015).

In general, students who experience math anxiety cannot think clearly and understand well in solving math problems. Feelings of anxiety, anxiety, and an increasingly fast heart rate make students unable to understand, accept, remember, and solve math problems properly (Tobias, 1990). This is supported by research conducted by several other researchers who state that there is an effect of math anxiety on cognitive abilities (Ashcraft, 2002; Auliya, 2016; Ekawati, 2015) Anxiety has been the subject of research for many years, and research continues with variables and different samples (Sevgi & Arslan, 2020).

In addition to math anxiety, things that are also related to logical thinking are intelligence which consists of three components, namely: (1) the ability to direct thoughts or direct actions; (2) the ability to change the course of action once the action has been implemented; (3) the ability to criticize oneself in (Saifuddin, 1996)**.** Intelligence can be understood as an individual's ability to think and act in a directed manner as well as to process and control the environment effectively (Winkel, 2004). It can be concluded that intelligence is an individual's ability to use his mind abstractly in solving a problem and the ability to adapt to a new environment.

A person's intelligence can be seen from his behavior in solving a problem and can be measured using an intelligence test (Purwanto, 2010). Intelligence has an influence on the achievement of students' learning achievements at school because good intelligence will give satisfactory results to the achievement of student's academic achievements, one of which is that students will be able to use their minds to think more logically in solving mathematical problems (Sternberg, 2012). his can be seen from research conducted by other researchers who state that intelligence has an influence on learning outcomes (Mufidah et al., 2018) and has a relationship with

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students' creativity (Setyabudi, 2011). Based on the existing problems, this study aims to determine the magnitude of the influence of Mathematics Anxiety and Intelligence on Students' Logical Thinking Ability.

METHOD

This research is a quantitative study using a survey method involving 96 respondents with an age range of 12-14 years distributed throughout the Jambi Province, Indonesia. The instrument in this study was to use a questionnaire about mathematics anxiety to measure students' mathematical anxiety levels, then test questions intelligence to measure ability tests intelligence, and logical thinking test questions to measure students' logical thinking skills.

The mathematics anxiety questionnaire was obtained from (Richardson & Suinn, 1972) which has been revised (Auliya, 2016; Brush, 1978; Ekawati, 2015; Plake & Parker, 1982; Santri, 2017; Suinn & Edwards, 1982; Sukendra, 2018; Wicaksono & Saufi, 2013) was then readjusted with the indicators used were the ability of students to understand, accept, and solve math problems (cognitive), attitudes that arise when students learn mathematics (affective), and changes in body temperature or anxiety in learning mathematics (somatic). The mathematics anxiety questionnaire was tested on 76 trial respondents who were in the study population. The 30 items of the questionnaire statement were then analyzed for their validity and reliability, to test the validity using Correlation Product Moment from 30 items of the questionnaire, the results of all items were in the valid category. As for the reliability test using Cronbach Alpha with a coefficient of r = 0.867 (reliable).

The Ability instrument intelligence uses the measuring instrument Intelligent Structure Test (IST)to obtain the respondent's IQ score. As a measure of intelligence, IST produces a mean score in the context of intelligence called Intelligence Quotient (IQ). IST was developed by Rudolf Amthauer with the basic theory of Primary Mental Abilities (PMA). PMA is a theory of basic intelligence developed by Lois Leon Thurstone where this theory describes seven basic abilities at the human cognitive level (Adinugroho, 2016). The total number of IST test questions is 176 items which are divided into 9 subtests, each of which indicates different aspects of the individual. The 9 subtests consist of; 1) complete the sentence (SE); 2) analogy (AN); 3) choose a word (WA); 4) similarity (GE); 5) counting tasks (RA); 6) series of numbers (ZA); 7) image/shape selection (FA); 8) dice questions (WÜ); 9) observation task (ME).

Logical thinking ability data was obtained from logical thinking test questions distributed to 96 respondents with 23 questions. The indicators used to measure the ability to think logically are: (a) able to draw analogy conclusions, generalize and construct conjectures; (b) draw logical conclusions based on the rules of inference, check the validity of arguments, and construct valid arguments. This

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logical thinking test indicator was obtained from (Tobin & Capie, 1981) and then revised by (Sumarmo et al., 2012) yang kemudian di revisi ole which was then revised by (Septiati, 2016) and subsequently readjusted by the researcher. After being considered by mathematicians, the test instrument was then tested on 76 students in the population, then an item validity analysis was carried out where as many as three items were declared not to meet the element of validity. The results of the reliability analysis obtained a score of 0.896 which means that the instrument is already in the reliable category.

The data analysis technique used in this research is multiple linear regression analysis. Because the variables used are more than one variable (Hasan, 2014). The independent variables in this study are mathematics anxiety and intelligence, while the dependent variable is the students' logical thinking ability. How the independent variable affects the dependent variable can be described as shown below.

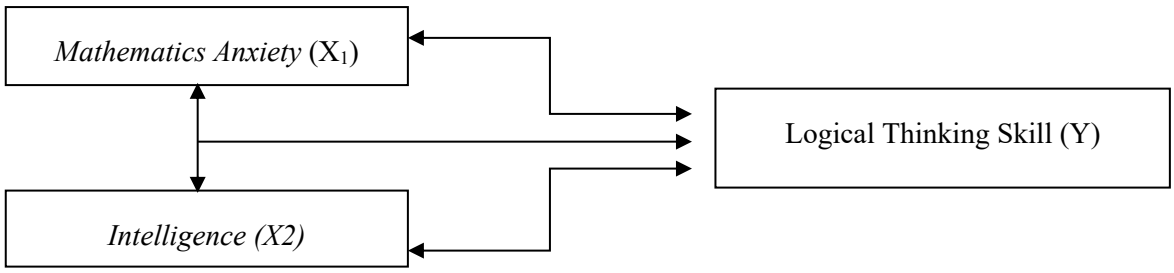

Figure 1. Regression analysis research design

Multiple Linear Regression is useful to find out how much influence Mathematics Anxiety (X1) and Intelligence (X2) have on Students' Logical Thinking Ability (Y). The regression equation used is Y = a + b1 x1 + b2 x2 + ...+ n xn + e, where Y is the dependent variable; a, b1, b2,....bn is the regression coefficient; x1,x2,.....xn is the independent variable.

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RESULT AND DISCUSSION

Result

The questionnaire data Mathematics anxiety distributed to the first 96 respondents were grouped by dividing into three intervals. The results of the calculation of the number of each interval can be seen in the following table.

Table 1. Distribution of categorization Mathematics Anxiety

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No.	Score	F	P	Category
1	X ≥ 94,33	16	16,67%	High
2	77,67 ≥ X < 94,33	49	51,04%	Medium
3	< 77,67	31	32,29%	Less

In Table 1 above it is known that from 96 students who have a high level of anxiety are 16 students (16.67%). While students who have moderate levels of anxiety are 49 students (51.04%), and students who have low levels of anxiety are 31 students (32.29%). Overall, it can be concluded that students are more likely to have medium levels of anxiety.

For capability data intelligence obtained from the results of distributing ability test questions intelligence to 96 respondents then grouped based on the classification presented in the following table.

Table 2. Frequency Distribution of Intelligence

Interval IQ	F	%	Taraf IQ
140 – and above	0	0	Genius
130 – 139	5	5	Very Intelligent
120 – 129	19	20	Intelligent
110 – 119	15	16	Above normal
90 – 109	40	42	Normal
80 – 89	9	9	Below normal
70 – 79	8	8	Idiot

Based on Table 2 above, it is known that the number of students who have an IQ above the average (intelligent) is 19 students (20%), students who have a normal IQ are 40 students (42%) and students who have an IQ below normal are 9 students (9%). Overall it can be concluded that students tend to have a normal IQ.

Furthermore, the results for logical thinking skills were obtained from the distribution of logical thinking test questions to 96 respondents which have been presented in the following table.

Table 3. Distribution of Categorization of Logical Thinking Ability

Score	F	%	Category
X ≥ 75	34	35,42	Good
60 ≤ X < 75	42	43,75	Medium
X < 60	20	20,83	Less

Based on Table 3 above, it is known that the good category was obtained by 34 students (35.42%), the medium category was obtained by 42 students (43.75%), and the less category was obtained by 20 students (20.83%). After knowing the results of mathematics anxiety, intelligence, and logical thinking skills. Furthermore, data analysis will be carried out using a multiple linear

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regression equation test. Before performing the multiple linear regression test, a prerequisite test or classical assumption test must be carried out.

The first classical assumption test is the normality test. The regression model is said to be normally distributed if the data plotting (dots) that describe the actual data follow a diagonal line (Ghazali, 2011). The results of the normality test in this study can be seen in the image below. (Ghazali, 2011). The results of the normality test in this study can be seen in the image below.

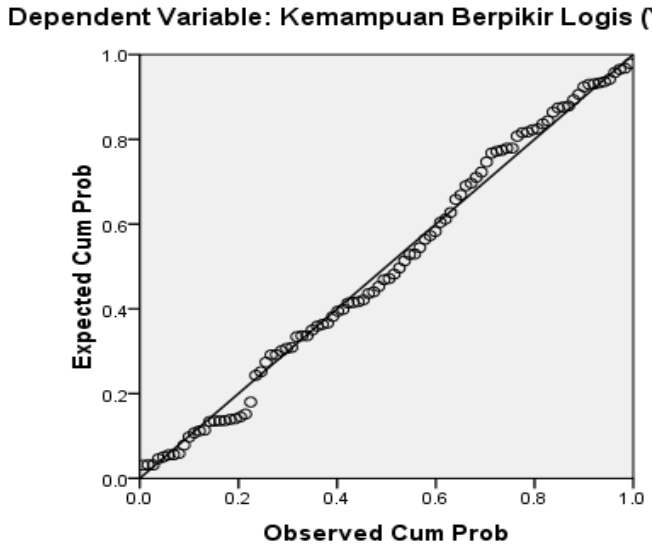

Figure 2. Normality Test Results

In Figure 2 above, it can be seen that the points follow a diagonal line. So the research data can be said to be normally distributed. After the normality test, the second classic assumption test is the multicollinearity test. Multicollinearity occurs if the VIF value is > 10.00 or the value is tolerance < 0.10. To determine the presence or absence of multicollinearity, it can be seen on the amount of tolerance and VIF (Ghazali, 2011). The results of the multicollinearity test show that the value is mathematics tolerance anxiety0.974, this means 0.974 > 0.10 while the VIF value is 1.027, this also means 1.027 < 10.00. Meanwhile, the value tolerance and VIF Intelligence have the same value as the variable Mathematics Anxiety. So it can be concluded that the data is free from multicollinearity symptoms.

Furthermore, a heteroscedasticity test was carried out. A variable is said to be free from heteroscedasticity cases if the residual value > 0.05. The results of the heteroscedasticity test show that the residual value of Mathematics Anxiety is 0.790, this means 0.790 > 0.05 and the residual value is Intelligence 0.950, this also means 0.950 > 0.05. So it can be concluded that the data is free from heteroscedasticity cases. The next process is the autocorrelation test. According to (Ghazali, 2011) there is no symptom of autocorrelation if the Durbin Watson value lies between du to (4 - du). The value of du is searched on the distribution of the values of the Durbin Watson table based on k

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(2) and N (96) with a significance of aa = 0.05, the value of du is 1.7103. Then the result of 4 – du is 2.2897. The result of the autocorrelation test is the Durbin Watson value of 1,800. Then the value of Durbin Watson lies between 1.7103 to 2.2897 or can be written in mathematics du (1.7103) <dw (1.800) <4 – du (2.2897). So it can be concluded that the data is free from autocorrelation symptoms.

Further tests were conducted to test the coefficient of determination (R2) The coefficient of determination obtained is 0.66. This shows that the independent variable affects the dependent variable by 66%. The coefficient of determination test is the last test for the classical assumption test. Furthermore, hypothesis testing is carried out. Hypothesis testing using multiple linear regression analysis. his analysis is used to obtain the effect and magnitude between several independent variables (X) on the dependent variable (Y). Hypothesis testing using partial t-test and simultaneous F-test. The results of hypothesis testing in the study can be seen in the following table.

Table 4. Hypothesis Testing

Statistical Test		**Count Value**	**Sig**	**Information**
Uji t	*Mathematics Anxiety (X_1)*	-0,693	0,049	H_0 rejected
	Intelligence (X_2)	2,542	0,013	H_0 rejected
Uji F		3,271	0,042	H_0 rejected

From Table 4 above, it can be seen that partially mathematics anxiety has a significant value of 0.049, which means a <0.05. Then H_0 is rejected, it is meaningful mathematics anxiety significant effect on the ability to think logically. The same thing also applies to the variables intelligence that has a sig value amounted to 0,013, which means a <0.05 then H_0 is rejected it may be said that intelligence gives a significant effect on the ability to think logically. Meanwhile, simultaneously or together mathematics anxiety and intelligence have a sig value of 0.042 which means a < 0.05 then H_0 is rejected. So it can be said that mathematics anxiety and intelligence have a significant influence on the ability to think logically.

Based on the several tests above, the multiple linear regression equation can be written as follows: Y = 59.636 – 0.080 X1 + 0.134 X2. Based on the multiple linear regression equation, it can be concluded that: (1) The constant value is 59.636. This means that if there is no change in the variables Mathematics Anxiety and Intelligence (the values of X1 and X2 are 0) then the Logical Thinking Ability of students is 59.636; (2) The value of the coefficient of Mathematics Anxiety (X1) is -0.080. This means that if mathematics anxiety (X1) increases by one unit and the assumption that intelligence and constants are zero, then the ability to think logically decreases by 0.080. This shows that mathematics anxiety harms the ability to think logically; (3) coefficient value Intelligence (X2) is 0.134. This means that if intelligence increases by one unit and the assumption that mathematics anxiety and constants are zero, then the ability to think logically will increase by 0.134. This shows that intelligence has a positive influence on the ability to think logically.

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Discussion

From the results of data analysis, it is known that mathematics anxiety has a negative influence on students' logical thinking skills. Research conducted by (Suinn, 1970) mathematics anxiety is still within the scope of psychology, stating that every individual has mathematical anxiety in himself, some people can overcome this anxiety but some are not (Richardson & Suinn, 1972). Endler & Edwards (1982) say that anxiety has prompted strong research concerns in recent decades, because this state is an emotional state that is supported by fear, anxiety, helplessness, and will be associated with learning outcomes (Hembree, 2015).

By research conducted by (Ekawati, 2015) states that there is a strong influence of anxiety on learning outcomes. Subsequent research conducted by (Gürefe & Bakalım, 2018) also said that there was a negative correlation between mathematics anxiety and student academic achievement. As the theory in the Turkish Language Institute (Türk Dil Kurumu-TDK) defines anxiety as an uncomfortable feeling that arises when a request is impossible to achieve (Sevgi & Arslan, 2020). Therefore, if feelings of anxiety and worry are allowed to continue, it will disrupt the conditions of student learning activities, so that students lack confidence in the abilities that exist within themselves.

Mathematics anxiety comes from the perception of students who think that mathematics is gloomy and never fun and can also come from the incompleteness of learning which in turn results in the unpreparedness of students (Tobias, 1990). In addition, the mental age of students who are not mature in accepting mathematics learning is also what causes "continuous lag". Anxiety in mathematics (mathematics anxiety) should remain in anticipation, their Somatic and behavior change is believed to contribute to cognitive decline because it interferes with the focus and comfort of students. Therefore, mathematics anxiety cannot be considered a normal phenomenon, because students' inability to adapt to lessons will cause students to experience difficulties and fears in mathematics, which in turn leads to low academic achievement and a decrease in students' mathematical achievement (Anita, 2014). This can have an impact on students' logical abilities because math problems are related to logical reasoning abilities in solving them. Some of the findings above can be used as a strong basis for establishing the negative influence of mathematics anxiety on students' logical thinking abilities.

Furthermore, for the results of data analysis, it is known that intelligence affects the logical thinking ability of students. If you look at the coefficient value intelligence in the multiple linear regression equation, intelligence has a positive influence on students' logical thinking abilities. This result has relevance to the research conducted by (Mufidah et al., 2018) which says that intelligence influences mathematics learning outcomes which are closely related to logical thinking. In addition, this result is also strengthened by the presence of several subtests in the measuring instrument

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Intelligenz Structure Test (IST) which represents an indication of logical thinking ability. The subtests in the measuring instrument Intelligenz Structure Test (IST) whose results can reflect logical thinking skills are sentence completion subtests (SE), analogies (AN), similarity (GE), and counting tasks (RA) (Kusdiyati, 2018). Some of the findings above indirectly support the influence of intelligence on students' logical thinking abilities as a form of fairness.

Intelligence melibatkan kemampuan untuk belajar dan beradaptasi dengan lingkungan yang baru dan selalu beruba Intelligence involves the ability to learn and adapt to a new and ever-changing environmenth (Sternberg, 2012). Intelligence includes aspects of the ability of how individuals pay attention, observe, remember, think, memorize, and other psychological forms (Veriansyah et al., 2018). David Wechsler in (Veriansyah et al., 2018) defines intelligence as a collection or totality of a person's ability to act with certain goals, think rationally, and deal effectively with his environment.

Students need to have sufficient intelligence and have the ability to survive or the ability to overcome difficulties in the problems they face. Therefore, it is necessary to create conditions for students who can bring out their creativity and other abilities in learning with a certain approach. In addition, it is necessary to increase the basic potential of students by providing exercises or tasks that require their intellectual abilities, both involving convergent thinking activities and divergent thinking activities (Setyabudi, 2011).

Raymond Cattell in Jatmika (2014) shows that intelligence includes two factors, fluid intelligence, and crystallized intelligence. Fluid intelligence is an innate, partially nonverbal, and culturally unaffected intelligence that is part of intellectual efficiency. Crystallized intelligence is highly culture-dependent and is used to perform tasks that require learning or habitual reactions, build relationships and understand conceptual interconnections of current events, adapt to new situations, and acquire knowledge easily through logical reasoning. From some of the descriptions above, intelligence abilities must continue to be developed, especially Crystallized Intelligence because mathematics is a subject that is closely related to calculations using logical reasoning in solving problems. Therefore, intellectual ability is a very important aspect in the process of absorption of mathematics (Mufidah et al., 2018). Intelligence ability is the ability to solve problems faced with reasoning and logic, so this intelligence ability is indispensable in solving and solving mathematical problems. With high intelligence, an individual will find it easier to understand, examine and solve problems properly.

Mathematics anxiety and intelligence are the two independent variables in this study. From the results of data analysis on the F test, it can be seen that the significant value of mathematics anxiety and intelligence is $0.042 < 0.05$. This shows that there is a significant influence between mathematics anxiety and intelligence together on the ability to think logically. The influence given by mathematics anxiety and intelligence on students' logical thinking skills is 66%, the rest is

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influenced by other factors such as learning motivation, emotional intelligence, and so on. High mathematics anxiety and intelligence have a low very bad impact on students' mathematical performance or achievement. So students must be able to control their anxiety and improve their mindset to achieve a good level of intelligence (Schillinger et al., 2018).

KESIMPULAN

Based on the results of the study, it can be concluded that there is an influence of mathematical anxiety and intelligence on the logical thinking ability of students together. The effect is given by mathematics anxiety and intelligence "together" is 66%, the rest is influenced by other variables not studied in this study From the conclusions above, it is suggested that teachers can create a good, warm and friendly learning environment to overcome math anxiety and reduce negative thoughts about mathematics. In addition, each student must always hone his abilities so that his level of intelligence is growing. Therefore, the teacher must also be able to choose the right teaching method so that students can adapt to the applied teaching method. For further research, it is hoped that researchers will conduct research involving more respondents so that the results obtained are more significant and cover a wide area. In addition, it can also develop mathematics learning methods and then test statistically whether a learning method can suppress mathematics anxiety and simultaneously can also develop intelligence, especially in crystallized.

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