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. This research involved 96 respondents from 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 an effect of mathematics anxiety and intelligence on students' logical thinking abilities.

Keywords: Intelligence; Logical Thinking Skill; Mathematics Anxiety

Abstrak. Tujuan penelitian ini untuk mengetahui besaran pengaruh mathematics anxiety dan intelligence terhadap kemampuan berpikir logis peserta didik. Penelitian ini melibatkan 96 responden pada sekolah menengah. Instrumen penelitian yang digunakan dalam penelitian ini adalah angket mathematics 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: Intelligence; Kemampuan Berpikir Logis; Mathematics Anxiety
INTRODUCTION

Mathematics has a vital 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 or the reality that occurs (Koray & Köksal, 2009).

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). 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.

Based on the explanation above, it can be concluded that the ability to think logically mathematically is thinking according to specific 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. There are several indicators to measure the logical thinking ability of these students, 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 internal factors within students who already have a negative view of mathematics, such as assuming that mathematics is a complex subject, causing anxiety when learning mathematics (Surya, 2017). In addition, there are also psychological factors in the form of negative attitudes from 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 attitude. 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 and Faust defined 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-solving math problems. Feelings of anxiety and an increasingly fast heart rate make students unable to understand, accept, remember, and solve math problems correctly (Tobias, 1990). It is supported by research conducted by several other researchers who state that math anxiety affects cognitive abilities (Ashcraft, 2002; Auliya, 2016; Ekawati, 2015). For many years, anxiety has been the subject of research, 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 and 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.

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). A person's intelligence can be seen from his behaviour in solving a problem and can be measured using an intelligence test (Purwanto, 2010). This fact can be seen from research conducted by other researchers who state that intelligence influences learning outcomes (Mufidah et al., 2018) and relates to students' creativity (Setyabudi,
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 aged 12-14 years distributed throughout the Jambi Province, Indonesia. This study used 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). The questionnaire was then readjusted with the indicators used 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 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). Rudolf Amthauer developed IST 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 divided into nine subtests, each indicating 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 logical thinking test indicator was obtained from (Tobin & Capie, 1981) and then
revised by Sumarmo et al. (2012) and 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 reliability analysis results 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 in Figure 1.

![Figure 1. Regression analysis research design](image)

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 \( Y = a + b_1 x_1 + b_2 x_2 + ...+ b_n x_n + e \), where \( Y \) is the dependent variable; \( a, b_1, b_2, ..., b_n \) is the regression coefficient; \( x_1, x_2, ..., x_n \) is the independent variable.

**RESULTS AND DISCUSSION**

**Result**

The questionnaire data on 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 Table 1.

| No. | Score  | F    | P     | Category |
|-----|--------|------|-------|----------|
| 1   | \( X \geq 94.33 \) | 16   | 16.67%| High     |
| 2   | \( 77.67 \geq X < 94.33 \) | 49   | 51.04%| Medium   |
| 3   | \( X < 77.67 \) | 31   | 32.29%| Less     |

In Table 1, it is known that of 96 students who have a high level of anxiety, 16 students (16.67%). While students who have moderate anxiety levels 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 anxiety levels.

For capability, data intelligence was obtained from distributing ability test questions intelligence to 96 respondents, then grouped based on the classification presented in Table 2.

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

Furthermore, the results for logical thinking skills obtained from the distribution of logical thinking test questions to 96 respondents have been presented in Table 3.

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

The first classical assumption test is the normality test. The regression model is normally distributed if the data plotting (dots) that describe the actual data follow a diagonal line (Ghazali, 2011). The normality test results in this study can be seen in Figure 2.
In Figure 2, 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. The presence or absence of multicollinearity can be seen in the amount of tolerance and VIF (Ghazali, 2011). The results of the multicollinearity test show that the value is mathematics tolerance anxiety 0.974, which means 0.974 > 0.10, while the VIF value is 1.027, which 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, which 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 (2) and N (96) with a significance of α = 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 fact 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. This analysis obtains 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 Table 4.

| Statistical Test | Count Value | Sig   | Information         |
|------------------|-------------|-------|---------------------|
| Uji t Mathematics Anxiety (X₁) | -0.693      | 0.049 | H₀ rejected         |
|                  | Intelligence (X₂) | 2.542  | 0.013 | H₀ rejected        |
| Uji F            | 3.271        | 0.042 | H₀ rejected         |

From Table 4, it can be seen that partially mathematics anxiety has a significant value of 0.049, which means a < 0.05. Then H₀ is rejected. Meaningful mathematics anxiety has a significant effect on the ability to think logically. The same thing applies to the variables intelligence with a sig value of 0.013, which means a < 0.05, then H₀ is rejected. It may be said that intelligence has 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 H₀ is rejected. So it can be said that mathematics anxiety and intelligence significantly influence the ability to think logically.

Based on the several tests above, the multiple linear regression equation can be written as follows: \( Y = 59.636 – 0.080 \times X₁ + 0.134 \times X₂ \). Based on the multiple linear regression equation, it can be concluded that: (1) The constant value is 59.636. This data 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 data means that if mathematics anxiety (X₁) increases by one unit and the assumption that intelligence and constants are zero, the ability to think logically decreases by 0.080. This data shows that mathematics anxiety harms the ability to think logically; (3) the coefficient value of Intelligence (X₂) is 0.134. It means that if intelligence increases by one unit and the assumption that mathematics anxiety and constants are zero, the ability to think logically will increase by 0.134. It shows that intelligence positively influences the ability to think logically.

**Discussion**

From the results of data analysis, it is known that mathematics anxiety negatively influences students' logical thinking skills. Research conducted by Suinn (1970) states that 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 do 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 supported by fear, anxiety, and helplessness and will be associated with learning outcomes (Hembree, 2015).

Research conducted by Ekawati (2015) states a strong influence of anxiety on learning outcomes. Subsequent research conducted by Gürefe & Bakalım (2018) also said a negative correlation between mathematics anxiety and student academic achievement. The Turkish Language Institute (Türk Dil Kurumu-TDK) theory 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.

Anxiety in mathematics (mathematics anxiety) should remain in anticipation. 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, resulting in the unpreparedness of students (Tobias, 1990). In addition, the mental age of students who are not mature in accepting mathematics learning also causes "continuous lag". Their somatic and behavioural 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 leads to low academic achievement and a decrease in students' mathematical achievement (Anita, 2014). It can impact 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 solid basis to establish the negative influence of mathematics anxiety on students' logical thinking abilities.

Some of the findings above indirectly support the influence of intelligence on students' logical thinking abilities as a form of fairness. Furthermore, to the results of data analysis, it is known that intelligence affects students' logical thinking ability. If we look at the coefficient value of intelligence in the multiple linear regression equation, intelligence positively influences students' logical thinking abilities. This result is relevant to the research conducted by Mufidah et al. (2018), which says that intelligence influences the mathematics learning outcomes closely related to logical thinking. In addition, this result is also strengthened by the presence of several subtests in the measuring instrument 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).
Intelligence involves the ability to learn and adapt to a new and ever-changing environment (Sternberg, 2012). Intelligence includes aspects of the ability of how individuals to pay attention, observe, remember, think, memorize, and other psychological forms (Veriansyah et al., 2018). David Wechsler (Veriansyah et al., 2018) defines intelligence as a collection or totality of a person's ability to act with specific 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 essential 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 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 vital aspect of the 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. An individual will find it easier to understand, examine, and solve problems correctly with high intelligence.

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. It shows a significant influence between mathematics anxiety and intelligence on the ability to think logically. The influence given by mathematics anxiety and intelligence on students' logical thinking skills is 66%, and the rest is influenced by other factors such as learning motivation, emotional intelligence, etc. High mathematics anxiety and intelligence have a terrible 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).
CONCLUSION

Based on the study results, 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%, and the rest is influenced by other variables not studied in this study. From the conclusions, 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 constantly hone his abilities to grow his level of intelligence. Therefore, the teacher must also be able to choose the proper 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 develop intelligence, especially in crystallized.

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