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The Influence Of Mathematical Anxiety And Logical-Mathematic Intelligence On Students' Learning Outcomes Through Critical Thinking Ability

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ABSTRACT
The research aims to determine the direct and indirect influence of mathematical anxiety, logical-mathematical intelligence, and critical thinking abilities on the learning outcomes acquired by students. Many things affect the teaching and learning process, both from outside the student's environment and from within the student himself. The unpreparedness of external and internal factors will create obstacles in the learning process of the student, which will then affect their learning outcomes. These include mathematical anxiety, mathematical logical intelligence, and critical thinking abilities. Students who experience mathematical anxiety tend to avoid conditions where they feel threatened and stressed. Of course, these people will think or assume negative thoughts about themselves. Mathematical logical intelligence plays a significant role for students in understanding abstract mathematics lessons. The challenge in the world of education is that it requires students to think at higher levels (HOTs). Critical thinking is a logical and natural thinking process that already exists in a person when facing changes in all sectors of life. The method used in this research is structural equation modeling (SEM), which will look at direct and indirect effects. The research results show that 1) mathematics anxiety has a significant positive influence on critical thinking abilities; 2) logical-mathematical intelligence has a significant positive influence on critical thinking abilities; 3) critical thinking skills have a significant positive influence on student learning outcomes; 4) mathematics anxiety has a significant positive influence on student learning outcomes; 5) logical-mathematical intelligence has a significant positive influence on student learning outcomes; 6) mathematics anxiety has a significant positive influence on student learning outcomes through critical thinking skills; and 7) logical-mathematical intelligence has an insignificant positive influence on student learning outcomes through critical thinking skills.

Keywords:
Mathematical anxiety; logical-mathematical intelligence; critical thinking ability; learning outcomes

INTRODUCTION

Success in learning can be influenced by factors from within the individual and outside the individual (Siagian, 2015). Many things influence the teaching and learning process, both from outside the student's environment and from within the student himself. Unpreparedness from external and internal factors will create obstacles in the student's learning process, which will then impact their learning outcomes.

Learning mathematics also really requires student readiness, both from the environment and from within themselves. Learning activities will take place optimally if students participate in the entire series of activities in their entirety and actively formulate each finding.

According to Priyani in Ikhsan (2019), students who experience mathematical anxiety tend to avoid conditions where they feel threatened and stressed. Of course, the person will think or assume negatively about themselves. Anxiety can have a good impact when it is still under control and considered normal because students' physical and intellectual performance is driven and strengthened by anxiety. It has a bad effect when it is uncontrolled and the level of anxiety is excessive. This kind of anxiety makes it difficult for students to concentrate.

A person's learning success cannot be separated from the characteristics he has. A person's intelligence plays a significant role in their success in learning. What plays a role in the mathematics learning process is mathematical logical intelligence. Mathematical logical intelligence plays a very important role for students in understanding abstract mathematics lessons. This is in line with the results of research by Mujiani (2016), which states that there is an influence of high and low mathematical logical intelligence on mathematics learning outcomes.

The challenge in the world of education is that it requires students to think at higher levels (HOTs). Critical thinking is a logical and natural thinking process that already exists in a person when facing changes in all sectors of life. Critical thinking is an ability that everyone must have. Critical thinking is one of the soft skills needed to improve your career and leadership in an organization. A person who thinks critically often has benefits for successful leadership. In particular, there are currently rapid changes in the field of education. Every student is required to have critical thinking skills to be able to compete when entering the world of work. According to Dwijananti and Yulianti (2010), the results of research conducted show that students' critical thinking skills that can be developed are: classifying, assuming, predicting, hypothesizing, evaluating, analyzing, and making conclusions. This research aims to:

1. Knowing the effect of mathematics anxiety on critical thinking skills.
2. Knowing the influence of logical-mathematical intelligence on critical thinking abilities.
3. Knowing the influence of critical thinking skills on student learning outcomes.
4. Knowing the direct influence of mathematics anxiety on student learning outcomes.
5. Knowing the direct influence of logical-mathematical intelligence on student learning outcomes.
6. Knowing the indirect influence of mathematics anxiety on mathematics learning outcomes through student learning outcomes.
7. Knowing the indirect influence of logical-mathematical intelligence on mathematics learning outcomes through student learning outcomes.

METHOD

The method used in this research uses survey research methods. According to Neuman W. Lawrence in [5] survey research is quantitative research. In survey research, researchers ask several people (respondents) about their beliefs, opinions, characteristics of an object, and past or present behavior. Survey research methods involve asking questions about one's own beliefs and behavior.

The target population in this research is all students of the Pamulang University Mathematics Study Program (UNPAM) in the odd semester of the 2023/2024 academic year, while the target population is all students in semester 1 (one) of the Pamulang University Mathematics Study Program in the odd semester of the 2023/2024 academic year. The sample is part of the number and characteristics of the population. The sample in this study were first-semester students who took the Statistical Methods course in the odd semester of the 2023–2024 academic year.

RESULTS AND DISCUSSION

Results

In this research, two analyses were carried out, namely the outer model and the inner model.

1. Outer Model Analysis (Measurement Model)

In the outer model analysis, two tests were used, namely testing the convergent validity and instrument reliability of the reflective second-order construct.

a. Convergent Validity Test

Convergent validity aims to determine the validity of each relationship between indicators and their latent constructs or variables. In this research, a loading factor limit of 0.700 will be used. Meanwhile, to evaluate discriminant validity, it can be seen using the AVE (average variance extracted) method for each construct or latent variable. The model has better discriminant validity if the square root of the AVE (average variance extracted) for each construct is greater than the correlation between the two constructs in the model.

Table 1. Outer Loading Value of the Convergent Validity Test

Indicator	Outer Loading				Description
	HBM	KBK	KLM	KM	
HBM	0.819				very good
KBK	0.808				very good
KLM	0.913				very good
KM	0.911				very good
HBM	0.899				very good
KBK		0.992			very good
KLM		0.980			very good
KM		0.981			very good
HBM			0.960		very good
KBK			0.957		very good
KLM			0.988		very good
KM			0.965		very good
HBM			0.971		very good
KBK			0.974		very good
KLM			0.845		very good
KM				0.971	very good
HBM				0.959	very good
KBK				0.968	very good
KLM				0.981	very good
KM				0.945	very good
HBM				0.986	very good
KBK				0.845	very good

Based on Table 1 for the convergent validity test, the entire indicator of the structure obtains an outer loading value of more than 0.700. This measurement is considered sufficient when the outer load value is above 0.700 (ghozali, 2006b). Then it can be concluded that the entire indicator is valid or has met the convergent validity criteria.

b. Discriminant Validity Test

Discriminant validity is done to ensure that each concept of each latent model is different from the other variables. The table below shows the discriminatory validity results of the research model by looking at cross-loading values.

Table 2. Cross Loading

	HBM	KBK	KLM	KM
HBM1	**0.819**	0.328	0.307	0.108
HBM2	**0.808**	0.193	0.282	0.128
HBM3	**0.913**	0.303	0.418	0.226
HBM4	**0.911**	0.383	0.431	0.373
HBM5	**0.899**	0.401	0.458	0.359
KBK1	0.377	**0.992**	0.234	0.336
KBK2	0.378	**0.980**	0.236	0.280
KBK3	0.376	**0.981**	0.199	0.303
KLM1	0.411	0.232	**0.960**	0.157
KLM2	0.441	0.241	**0.957**	0.156
KLM3	0.436	0.201	**0.988**	0.106
KLM4	0.411	0.189	**0.965**	0.090
KLM5	0.437	0.205	**0.971**	0.108
KLM6	0.411	0.205	**0.974**	0.108
KLM7	0.438	0.231	**0.845**	0.205
KM1	0.289	0.324	0.125	**0.971**
KM2	0.250	0.253	0.139	**0.959**
KM3	0.308	0.359	0.127	**0.968**
KM4	0.267	0.281	0.103	**0.981**
KM5	0.284	0.239	0.121	**0.945**
KM6	0.263	0.314	0.102	**0.986**
KM7	0.319	0.280	0.215	**0.845**

From the results of the cross-loading estimates in Table 2, it is indicated that the loading value of each indicator item is against its construction of the value of cross-load. Thus it can be concluded that all structures or latent variables already have a better discriminant validity than the indicators in the other blocks.

c. Validity of Discrimination Test with AVE

To evaluate the validity of discrimination can be seen with the AVE (Average Variance Extracted) method for any structure or latent variable. The model has better discriminatory validity when the square root of AVE for each structure is greater than the correlation between the two structures within the model.

Table 3. Average Variance Extract (AVE)

Variable	Average Variance Extract (AVE)
HBM	0.759
KBK	0.969
KLM	0.907
KM	0.906

Based on Table 3, the Average Variance Extract (AVE) value of the entire indicator of the structure obtains a value above 0.500. This measurement is considered sufficient if the minimum average variance extract value is 0.500 [6]. It can then be concluded that there is therefore no convergent validity problem in the tested model.

Table 4. AVE Root Value and Correlation Between Latent Variables

Construct	HBM	KBK	KLM	KM
HBM	**0.871**			
KBK	0.383	**0.984**		
KLM	0.449	0.227	**0.953**	
KM	0.299	0.312	0.141	**0.952**

Based on Table 4, each number weighed is the AVE (average variance extracted) root value of each structure, and the unweighed number is the correlation value between the structure and the other structure in the model. So it can be concluded from the output of Table 4 and Table 5 that all constructions meet the criteria of discriminatory validity.

d. Composite Reliability Test

In the construct reliability test, composite reliability tests measure the true reliability value of a variable, whereas Cronbach's alpha measures the lower bound reliability of the variable so that the value of the composite is greater than 0.700 and the Cronbach alpha value is greater than 0.700.

Table 5. Uji Composite Reliability

Construct	*Composite Reliability*
HBM	0.940
KBK	0.989
KLM	0.986
KM	0.985

Based on Table 5, the Composite Reliability Test, if the entire structure is declared reliable or all structures have good reliability with a composite reliability value greater than 0.700, then it can be concluded that all constructions have good reliability.

e. Cronbach's Alpha Test

To test Contruct Reliability can also be done by looking at the values of Cronbach's Alpha test.

Table 6. Cronbach's Alpha Test

Contruct	*Cronbach's Alpha*
HBM	0.923
KBK	0.984
KLM	0.983
KM	0.982

Based on Table 6 and Cronbach's alpha testing, if the entire structure is declared reliable or all structures have good reliability with a Cronbach's alpha value greater than 0.700, then it can be concluded that all constructions have good reliability.

2. Structural Model Analysis (Inner Model)

a. R-Square value

The R-square value (R^2) is used to estimate how much the influence of a particular independent latent variable on a dependent late variable is.

Tabel 7. R-square Value (R^2)

Variabel	Nilai R-*Square*
HBM	0.311
KBK	0.131

Based on table 7, it gives an R-square (R2) value of 0.131 for critical thinking ability (KBK), which means that mathematical anxiety (KM) and mathematical logical intelligence (KLM) can explain critical thinking ability (KBK) by 13.1%, while the rest is influenced by other factors.

Then, Table 7 also gave an R-square (R2) of 0.311 for Student Learning Outcomes (HBM), which means that mathematical anxiety (KM), mathematical logical intelligence (KLM), and critical thinking ability (KBK) are capable of explaining 31.1% of student learning outcomes, while the rest are influenced by other factors.

b. *Direct Effects*

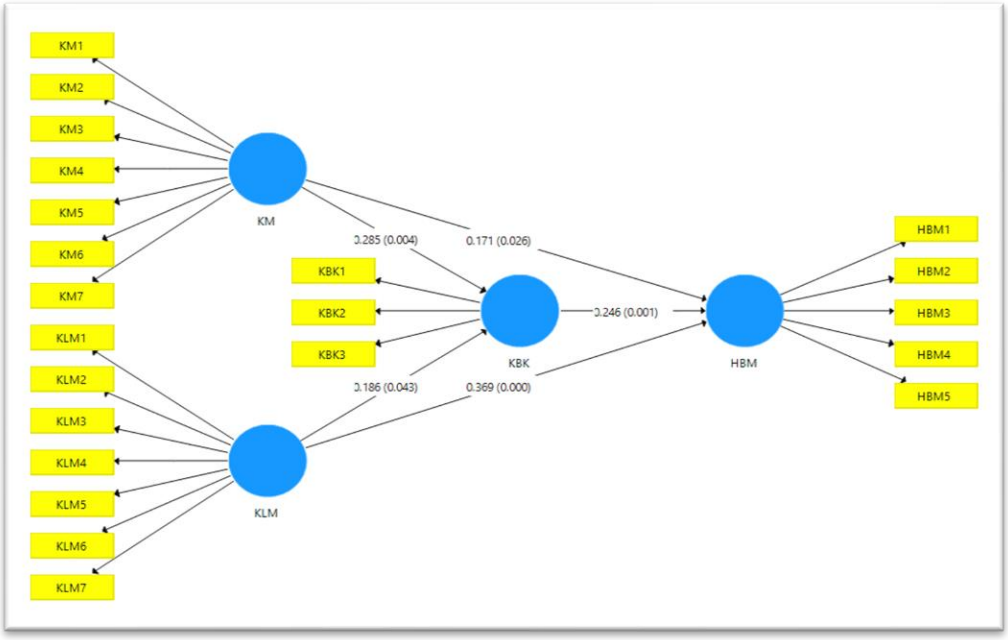

Figure 1. Structural Model Analysis

Figure 1 is an analysis of a direct effect test model of mathematical anxiety (KM) and logical intelligence (KLM) on student learning outcomes (HBM) through critical thinking skills (KBK).

Table 8. Direct Effects

	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	T *Statistics* (|O/STDEV|)	*P-Values*
KBK -> HBM	0.246	0.235	0.075	3.265	**0.001**
KLM -> HBM	0.369	0.376	0.088	4.185	**0.000**
KLM -> KBK	0.186	0.197	0.092	2.033	**0.043**
KM -> HBM	0.171	0.174	0.077	2.227	**0.026**
KM -> KBK	0.285	0.284	0.100	2.862	**0.004**

Table 9. Direct Impact Hypothesis Testing (Direct Effects)

Hypothesis	Konstruk	Keputusan
1	There is the influence of mathematical anxiety on the ability to think critically.	Hypothesis 1 (H1) accepted
2	There is the influence of logical-mathematical intelligence on the ability to think critically	Hypothesis 2 (H_2) accepted
3	There is an influence of critical thinking on student learning outcomes.	Hypothesis 3 (H_3) accepted
4	There is a direct influence of mathematical anxiety on student learning outcomes.	Hypothesis 4 (H_4) accepted
5	There is a direct influence of logical-mathematical intelligence on student learning outcomes.	Hypothesis 5 (H_5) accepted

c. ***Indirect Effects***

The results of testing the hypothesis of the direct influence of mathematical anxiety and logical-mathematical intelligence on student learning outcomes through critical thinking skills are as follows:

Table 10. Indirect Effects

	Original Sample (O)	*Sample Mean* (M)	*Standard Deviation* (STDEV)	T *Statistics* (|O/STDEV|)	*P-Values*
KLM -> KBK -> HBM	0.046	0.047	0.028	1.635	**0.103**
KM -> KBK -> HBM	0.070	0.067	0.034	2.045	**0.041**

Tabel 11. Testing Indirect Influence Hypothesis (Indirect Effects)

Hypothesis	Konstruk	Keputusan
6	There is an indirect influence of mathematical anxiety on the results of learning mathematics through student learning.	Hypothesis 6 (H_6) accepted
7	There is an indirect influence of logical-mathematical intelligence on mathematical learning through student learning.	Hypothesis 7 (H_7) rejected

Discussion

The results of testing the hypothesis of the direct influence of mathematical anxiety and logical-mathematical intelligence on student learning outcomes through critical thinking skills are as follows:

1. There is a direct positive influence between mathematical anxiety and critical thinking capacity is 0.285 which means that if the mathematical anxiousness increases by one unit then the critical thought capacity can increase by 28.5%. The p-value is 0.004 < 0.05 so accept the hypothesis (H_1 accepted) which means the direct influence of mathematic anxieties on critical thinking ability is statistically significant or significant. The findings are also in line with the findings of a study conducted by Ashcraft & Krause (2007) that mathematical anxiety can affect working memory, which is an important part of critical thinking. People who experience math anxiety show a decrease in working memory while doing math tasks, thus affecting their ability to think critically. Maloney & Beilock (2012) also found that mathematical anxiety has an impact on an individual's ability to solve complex mathematics problems. There is a high level of anxiety associated with a decrease in problem-solving and critical-thinking skills. So it was concluded that reducing math anxiety can help improve critical thinking skills and overall math performance. Anxiety can cause individuals to avoid challenges that require critical thinking. When faced with complex mathematical problems, anxious students may be more likely to feel desperate and abandoned, avoiding exercises that can enhance their critical thinking skills.
2. There is a direct positive influence between mathematical logic intelligence and critical thinking capacity is 0.186 which means if mathematic logical intelligence increases by one unit then critical thought capacity can increase by 18.6%. The p-value value is 0.043 < 0.05 so accept the hypothesis (H_2 accepted) which means the direct influence of mathematics logic intellect on critical thinking capacities is statistically significant or significant. Norris & Ennis (1989) in their book explain that logic and mathematics are key components in the development of critical thinking skills. This skill involves logical analysis and evaluation of arguments that often use mathematical principles. According to Suryadi & Fatimah (2017) the research investigated the relationship between mathematical logic intelligence and critical thinking ability of students in Indonesia. The results showed that there was a significant positive correlation between the two variables. Students with high mathematic logic Intelligence tended to have better critical-thinking abilities. Thus, it can be concluded that mathematical logic intelligence plays an important role in the development of critical thinking skills. Increased mathematical logic intelligence through appropriate learning methods can have a positive impact on students' ability to think critically. Developing mathematical logic intelligence through effective mathematics learning can improve students' ability to think critically. Using learning methods that involve solving mathematical problems actively can enhance both of these abilities [11].

3. There is a direct positive influence between the ability to think critically on student learning outcomes is 0.246 which means that if the ability of critical thinking increases one unit then the student's learning outcome can increase by 24.6%. With the p-value 0.001 < 0.05 so accept the hypothesis (H_3 accepted) which means the direct influence of the skill of critical thinking on students' learning output is significant or statistically significant. In line with the results of the research carried out by Sumarno (2016) showing that the ability to think critically has a positive influence on student learning outcomes. Students who have high critical thinking abilities tend to have better learning outcomes compared to students who have low essential abilities of thinking. Facione & others (2011) found that the ability to think critically was strongly correlated with academic performance. Students who showed strong critical thinking skills tended to have better academic results. It means that the ability to think critically plays an important role in improving student learning outcomes. Learning methods that support the development of critical thinking skills can have a positive impact on student academic achievement.
4. There is a direct positive influence between the mathematical anxiety on student learning outcomes is 0.171 which means that if the Mathematical Anxiety is increased by one unit then the student's learning outcome can increase by 17.1%. With the p-value value is 0.026 < 0.05 so accept the hypothesis (H_4 accepted) which means the direct influence of mathematic anxieties on student study outcome is statistically significant or significant. The results above are also in line with many studies showing that mathematical anxiety has a negative impact on mathematics learning outcomes. Students who experience mathematic anxieties tend to have lower scores compared to students who do not experience them. This happens because anxiety can disrupt concentration, reduce the ability to remember information, and impede the problem-solving process. Research conducted by Rahmawati & Setiawan (2015) found that students with high levels of mathematical anxiety had lower learning performance compared to students with low levels of anxiety.
5. There is a direct positive influence between mathematical logical intelligence and student learning outcomes is 0.369 which means that if the mathematical logic intelligence increases by one unit then the student's learning outcome can increase by 36.9%. With the p-value value is 0,000 < 0.05 so accept the hypothesis (H_5 accepted) which means the direct influence of mathematic logic Intelligence on student study outcomes is statistically significant or significant. Research carried out by Wijaya (2016) revealed that there was a significant positive correlation between mathematical logic skills and high school students mathematics learning achievements in Yogyakarta.

The results of the test hypothesis of the indirect influence of mathematical anxiety and logical-mathematical intelligence on student learning outcomes through critical thinking skills are as follows:

1. There is an indirect positive influence of mathematical anxiety on learning outcomes through critical thinking is 0.070 which means that if the mathematics

anxieties increase by one unit then the student's learning outcome can increase indirectly through the ability to think critically by 7.0%. The p-value is 0.041 < 0.05 so accept the hypothesis (H_6 accepted) which means the indirect influence of mathematic anxiety on the learning output of students through critical thought ability is significant or statistically significant.

2. There is an indirect positive influence of mathematical logic intelligence on learning outcomes through critical thinking is 0.046, which means that if mathematic logical intelligence increases one unit then the student's learning outcome can be increased indirectly through the ability to think critically by 4.6%. With a p-value of 0.103 > 0.05 thus reject the hypothesis (H_7 rejected) which means the indirect influence on the learning output of the student through the critical thought ability is statistically meaningless or insignificant.

CONCLUSION

From the results of the analysis, it can be concluded that the direct and indirect influence of mathematical anxiety and logical-mathematical intelligence on the learning outcome of students through the ability to think critically is as follows:

1. Mathematical anxiety has a significant positive influence on the ability to think critically.
2. Logical-mathematical intelligence has a significant positive influence on the ability to think critically.
3. The ability to think critically has a significant positive influence on student learning outcomes.
4. Mathematical anxiety has a significant positive influence on student learning outcomes.
5. Logical-mathematical intelligence has a significant positive influence on student learning outcomes.
6. Mathematical anxiety has a significant positive influence on student learning outcomes through critical thinking skills.
7. Logical-mathematical intelligence has a positive influence that is not significant on student learning outcomes through the ability to think critically.

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