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The Influence of Mathematical Logical Intelligence on Student Learning Outcomes in Linear Algebra Courses

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Abstract

The purpose of this study was to determine the effect of mathematical logical intelligence on student learning outcomes in Linear Algebra courses. The research method used is quantitative. The sampling technique used in this study was simple random sampling. Data collection in this study used a mathematical logical intelligence test of 20 multiple choice questions and a test of student learning outcomes in linear algebra courses of 5 description questions. The variables in this study consisted of independent variables and dependent variables. The independent variable in this study is mathematical logical intelligence (X), while the dependent variable in this study is student learning outcomes in Linear Algebra courses (Y). The instrument test in this study consisted of validity test, distinguishing power, difficulty level and reliability test. The classical assumption test in this study consists of normality test and linearity test. The data analysis technique used simple linear regression. The result of this study is that there is an influence between mathematical logical intelligence on student learning outcomes in linear algebra courses of 0.527 or 53%. While the other 47% is influenced by other variables outside this study.

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INTRODUCTION

Linear Algebra is one of the basic compulsory courses in the Informatics Engineering study program taken in semester 2. The material discussed in the Linear Algebra course is matrices, systems of linear equations, vectors, eigenvalues and eigenvectors. Since linear algebra is a compulsory course, it is expected that students can master the course well. However, in reality there are still many students whose mastery of linear algebra material is still low.

The low mastery of linear algebra material is because some students still consider linear algebra to be a difficult course so that students' desire to try to practice linear algebra material is quite low. Tristanti and Nusantara (2023) stated that one of the subjects that is difficult to learn for students is linear algebra.

Students tend to only write back and imitate what has been explained by the teacher. If given a problem that is slightly different from the example, students tend to have difficulty. So, this causes student learning outcomes also tend to be lacking. However, there are some students who tend to actively ask if there is material that they do not understand, the desire to try to solve problems is also good, so that these students get good learning outcomes as well. Learning outcomes are the results or results that a person gets after going through the learning process (Lestari, 2014). Learning outcomes are also the final results obtained by students after participating in the learning process which is marked by a value scale in the form of letters or numbers that can be used as a measure of whether or not students are successful in learning mathematics (Firmansyah, 2015). Based on several opinions regarding learning outcomes, it can be concluded that linear algebra learning outcomes are the final results in the form of grades obtained by students after following the Linear Algebra lecture process.

Low student interest and motivation in courses related to numbers can affect mathematical logical intelligence. The amount of material related to variables in linear algebra courses makes students less interested in the material. In addition, the low ability of students to solve exercise problems that are different from the examples given, shows that the logic of students does not run well or does not run as it should. The material in the Linear Algebra course is mostly related to numbers, calculations, variables ranging from matrices to eigenvectors. According to Sudrajat, the lack of student understanding causes linear algebra to be considered an abstract, complicated and boring subject, causing students to be unmotivated in learning linear algebra (Dafid, Wibawa, & Situmorang, 2022). If student interest is low in linear algebra courses, it can affect the acquisition of student learning outcomes.

There are 2 factors that influence student learning outcomes in linear algebra, namely internal factors and external factors. External factors include environment, family, friends. Meanwhile, one of the internal factors is the intelligence that each person has. There are 8 kinds of intelligence categories according to Gradner, namely linguistic intelligence, mathematical logical intelligence, visual and spatial intelligence, musical intelligence, interpersonal intelligence, intrapersonal intelligence, kinesthetic intelligence and naturalist intelligence (Shahrokhi, Ketabi, & Dehnoo, 2013). Mathematical logical intelligence is closely related to mathematics (Supardi, 2014). Mathematical logical intelligence is the ability to use numbers effectively and reason well (Al-Salameh, 2012). Logical thinking skills are needed by individuals during activities in making decisions, drawing conclusions and solving problems, where someone who has mathematical logical intelligence has the characteristics of being able to think according to logical rules, based on structure, according to appropriate rules, classifying, categorizing and being able to analyze numbers (Sari, 2020). Nurzaelani and Wibowo (2015) stated that mathematical logical intelligence is very important for every student, especially in mathematics, where the material includes algebra, measurement and geometry, opportunities, statistics, trigonometry and calculus. From several opinions that have been described, mathematical logical intelligence is the ability to count using numbers, the ability to think logically and the ability to solve mathematical problems that use variables.

The characteristics of people who have prominent logical intelligence include having a strong ability to reason, sequence, think in causal patterns, create hypotheses and look for conceptual regularities or numerical patterns (Ula, 2013; Nurzaelani & Wibowo, 2015). The characteristics of mathematical logical intelligence are having prominent abilities in the fields of logic, causal patterns, classification and categorization, abstraction, symbolization, inductive and deductive thinking, counting, playing with numbers, scientific thinking and syllogism (Widiastuti, 2015). Based on several opinions regarding the characteristics of people who have mathematical logical intelligence, there are 4 indicators of mathematical logical intelligence used in this study, namely students are able to solve problems related to calculation (numerical), students are able to solve problems related to algebra (containing variables), students are able to solve problems about patterns / series, students are able to solve problems related to logic.

In the research conducted by Dafid et al. (2022) provides results that mathematical logical intelligence makes a major contribution to improving student learning outcomes in Linear Algebra lectures. Sari (2019) in the research conducted obtained the results that there is a significant influence between mathematical logical intelligence and student learning outcomes, which means that students with high mathematical logical intelligence will be easy to learn and understand mathematics so that students are quick in solving math problems. While research by Santoso and Utomo (2020) obtained the result that mathematical logical intelligence partially has no significant effect on student learning outcomes.

Some research results show that mathematical logical intelligence does have an influence on learning outcomes, but there are also some who say that mathematical logical intelligence has no effect on learning outcomes. Therefore, this study tries to determine the magnitude of the influence of mathematical logical intelligence on the learning outcomes of undergraduate students of Informatics Engineering in Linear Algebra courses. In connection with this description, the purpose of this study is to determine the magnitude of the influence of mathematical logical intelligence on student learning outcomes in Linear Algebra courses.

RESEARCH METHODS

The research conducted included a type of quantitative research. The subjects of this study were 1st year students in the 2022 Linear Algebra course, namely classes 1D, 1E, 1F and 1J. The population used was 130 students. The sampling technique used in this study was simple random sampling. According to (Riduwan, 2003) simple random sampling is a way of taking samples from members of the population at random without paying attention to the strata / levels in the population members. Determination of the number of samples using the Slovin formula (Putri & Kartika, 2017; Wahyuniar et al., 2021). From the calculation using the formula, the sample used in this study was 56 students. Because the number of students in each class is not the same, the sampling from each class is 18 students taken from classes 1D and 1E, 13 students from class 1F and 7 students from class 1J.

The independent variable (X) used in this study is mathematical logical intelligence, while the dependent variable (Y) is student learning outcomes in Linear Algebra courses. Data collection techniques for mathematical logical intelligence and linear algebra learning outcomes are by using tests. For the mathematical logical intelligence test in the form of multiple choice. There are 4 indicators used for the mathematical logical intelligence test which are presented in Table 1.

Table 1. Logical mathematical intelligence test indicators

Indicator	Number of items
1. Students are able to solve problems related to calculation (numerical)	5
2. Students are able to solve problems related to algebra (containing variables),	5
3. Students are able to solve problems about patterns/sequences	5
4. Students are able to solve problems related to logic	5

Table 1 is an indicator of the mathematical logical intelligence test, where there are 4 indicators for the mathematical logical intelligence test. Each indicator consists of 5 questions/question items. Thus, there are 20 questions for the mathematical logical intelligence test.

As for the linear algebra learning outcomes test in the form of descriptions. For the student learning outcomes test in linear algebra courses there are 5 indicators presented in Table 2.

Table 2. Student learning outcomes test indicators on linear algebra

Indicator	Number of items
1. Students are able to calculate operations on matrices	1
2. Students are able to solve SPL with Gauss Jordan elimination	1
3. Students are able to determine orthogonal projections on vectors	1
4. Students are able to calculate eigenvalues	1
5. Students are able to calculate eigenvectors	1

Table 2 states the indicators of the student learning outcomes test on linear algebra which consists of 5 indicators, each indicator has 1 description test question. Thus, there are 5 description questions for the student learning outcomes test in linear algebra courses.

The instrument test in this study used validity, distinguishing power, difficulty level and reliability tests which were tested on 40 students. Instrument tests consisting of validity, distinguishing power, difficulty level and reliability were carried out manually using Excel.

The classic assumption tests used are normality test and linearity test. Then the data analysis technique in this study is simple linear regression. The classic assumption test and data analysis tools in this study used SPSS version 23.

The assessment of mathematical logical intelligence test refers to the formula found in Romika and Amalia (2014) and Indaswari et al. (2021).

RESULTS AND DISCUSSION

Validity Test

Nurzaelani and Wibowo (2015) stated that if r is greater than $r_{\alpha=0.05}$, then the item is considered valid, whereas if r is smaller or equal to $r_{\alpha=0.05}$, then the item is considered invalid. In this study there were 40 respondents to take the test of mathematical logical intelligence and linear algebra learning outcomes. The criteria used to determine the validity of the items is by comparing the correlation coefficient (r) and $r_{\alpha=0.05}$. The value of the $r_{\alpha=0.05}$ with N=40 is 0.312. The validity of mathematical logical intelligence items consisting of 20 questions is shown in Table 3.

Table 3. Validity of mathematical logical intelligence test

Item	*r*	Criteria	Item	*r*	Criteria
1	0,371	Valid	11	0,412	Valid
2	0,357	Valid	12	0,364	Valid
3	0,355	Valid	13	0,350	Valid
4	0,580	Valid	14	0,773	Valid
5	0,696	Valid	15	0,700	Valid
6	0,464	Valid	16	0,352	Valid
7	0,517	Valid	17	0,379	Valid
8	0,755	Valid	18	0,494	Valid
9	0,572	Valid	19	0,582	Valid
10	0,700	Valid	20	0,320	Valid

Based on the results of the calculations shown in Table 3 about the validity of mathematical logical intelligence items, it can be seen that 20 items have an r is greater than $r_{\alpha=0.05}$=0.312, so all test questions are declared valid.

Similar to the validity of items on mathematical logical intelligence, the validity of items on student learning outcomes is considered valid if r is greater than $r_{\alpha=0.05}$. The validity of the items of student learning outcomes consisting of 5 questions is presented in Table 4.

Table 4. Item validity of student learning outcomes

Item	1	2	3	4	5
r	0,68	0,82	0,90	0,87	0,89
Criteria	Valid	Valid	Valid	Valid	Valid

Based on the results of the calculations in Table 4 regarding the validity of the items of student learning outcomes, it can be seen that 5 items have an r is greater than $r_{\alpha=0.05}$, then all test questions are declared valid.

Distinguishing Power Test

A question item is said to have good differentiation if the differentiation index is equal to or more than 0.30 ($D \geq 0.30$) (Budiyono, 2011). The mathematical logical intelligence discriminating power (*DP*) test is presented in Table 5.

Table 5. Differentiating power of mathematical logical intelligence

Item	*DP*	Criteria	Item	*DP*	Criteria
1	0,35	Good	11	0,35	Good
2	0,35	Good	12	0,40	Good
3	0,35	Good	13	0,35	Good
4	0,60	Good	14	0,70	Good
5	0,60	Good	15	0,60	Good
6	0,40	Good	16	0,30	Good
7	0,40	Good	17	0,30	Good
8	0,65	Good	18	0,40	Good
9	0,40	Good	19	0,45	Good
10	0,60	Good	20	0,30	Good

Based on the results presented in Table 5, it can be concluded that all items on the mathematical logical intelligence test have good differentiating power because the value of differentiating power is greater than or equal to 0.30. Furthermore, the differentiating power of student learning outcomes is presented in Table 6.

Table 6. Distinguishing power of student learning outcomes

Item	1	2	3	4	5
DP	0,33	0,3	0,3	0,3	0,3
Criteria	Good	Good	Good	Good	Good

Based on the results presented in Table 6, it can be concluded that all items on the student learning outcomes test have good differentiating power because the value of differentiating power is greater than or equal to 0.30.

Difficulty Level

The level of difficulty test is carried out to determine the level of difficulty in each question including in the easy, medium or difficult category. As stated by Nurzaelani and Wibowo (2015) that the criteria for the level of difficulty of test items (*DL*) are *DL* = 0.00 – 0.30 difficult; *DL* = 0.31 – 0.70 moderate; *DL* = 0.71 – 1.00 easy. The test of the level of difficulty for mathematical logical intelligence questions is presented in Table 7.

Table 7. Level of difficulty of mathematical logical intelligence test

Item	*DL*	Criteria	Item	*DL*	Criteria
1	0,73	Easy	11	0,8	Easy
2	0,7	Medium	12	0,7	Medium
3	0,8	Easy	13	0,5	Medium
4	0,6	Medium	14	0,5	Medium
5	0,6	Medium	15	0,5	Medium
6	0,6	Medium	16	0,7	Medium
7	0,6	Medium	17	0,5	Medium
8	0,5	Medium	18	0,7	Medium
9	0,8	Easy	19	0,4	Medium
10	0,6	Medium	20	0,7	Medium

Based on the calculation results that have been presented in Table 7 regarding the level of difficulty in mathematical logical intelligence questions, there are 16 questions that have moderate criteria while the other 4 questions have easy criteria. Furthermore, the test of the level of difficulty on the question of student learning outcomes is presented in Table 8.

Table 8. Level of difficulty of student learning outcomes test

Item	1	2	3	4	5
DL	0,645	0,73	0,7	0,81	0,61
Criteria	Medium	Easy	Medium	Easy	Medium

Based on the calculation results in Table 8 about the level of difficulty of student learning outcomes in linear algebra courses, there are 3 questions that have moderate criteria while the other 2 have easy criteria.

Reliability

A variable is said to be reliable if it provides a value of Cronbach Alpha is greater than 0,7 (Riyadi & Mulyapradana, 2017). The result of the reliability test of mathematical logical intelligence is 0.85. While the reliability test result of Linear Algebra learning outcomes is 0.88. The reliability test results of the two variables show the results is greater than 0.7, so that the two variables are declared reliable and suitable for simple regression tests.

Normality Test

The normality test is carried out to show that the sample data comes from a normally distributed population. A data is said to be normally distributed if the *p*-value is greater than α=0.05 (Ghozali, 2006). The results of the normality test of the independent variable (mathematical logical intelligence) and the dependent variable (student learning outcomes) are presented in Table 9.

Table 9. Normality test results

Variable	Test-Statistic	*p*-value	Description
Logical Mathematical Intelligence	0.073	0.200>0.05	Normal
Student Learning Outcomes	0.115	0.061>0.05	Normal

In Table 9 of the normality test results, the results obtained on mathematical logical intelligence *p*-value=0.200 is greater than α=0.05, it can be concluded that the data on the mathematical logical intelligence variable is normally distributed. In student learning outcomes in linear algebra, the results of *p*-value=0.061 is greater than α=0.05, it can be concluded that the data on the variable student learning outcomes in linear algebra is normally distributed.

Linearity Test

Linearity test is conducted to determine the linearity of the relationship between the independent variable and the dependent variable. In this study, the independent variable used is mathematical logical intelligence while the dependent variable is student learning outcomes. The relationship between the independent variable and the dependent variable is said to be linear if the *p*-value

on deviation from Linearity is greater than α=0.05 (Ghozali, 2006). The results of the linearity test between the two variables are presented in Table 10.

Table 10. Linearity test results

Variable	Deviation from Linearity	*p*-value
Math. logical intelligence (X) with Learning Outcomes (Y)	0.759	0.696>0.05

In Table 10, about the results of the linear test, the results show that the relationship between mathematical logical intelligence and student learning outcomes is *p*-value=0.696 is greater than α=0.05, it can be concluded that the relationship between variables X and Y is linear. After the classical assumption test has been carried out and meets all the criteria, the next step is to look for a simple regression test using SPSS.

Simple Regression Test

The results analysis of the simple regression test, is to determine the significance of the influence of mathematical logical intelligence on learning outcome, are presented in Table 11.

Table 11. Simple linear regression

Variable	Regression Coefficient	*t*	*p*-value
Constant	12.396		
Math. logical intelligence		7.752	0.000
F	60.088		0.000
R	0.726		
R^2	0.527		

Table 11 shows that the regression equation obtained is as follows Y=12.396+7.752X. The constant value obtained is 12.396, indicating that mathematical logical intelligence (X) if it does not change, then the amount of student learning outcomes (Y) is 12.396. The regression coefficient of the mathematical logical intelligence variable is 7.752, meaning that if there is an increase in the mathematical logical intelligence variable by one unit, it will cause the student learning outcomes variable to increase by 7.752 units. Furthermore, it is also known that F=60.088 with *p*-value=0.000 is less than α=0.05, indicating that the influence of mathematical logical intelligence on student learning outcomes is significant.

The magnitude of the relationship between the mathematical logical intelligence variable on student learning outcomes in linear algebra courses is 0.726 which is shown in the R=0.726. The magnitude of the influence of the mathematical logical intelligence variable on student learning outcomes is 0.527 or 53% which is shown in the R^2=0.527, while for 47% of the student learning outcomes variable is influenced by other variables outside the study. Thus, this shows that there is an influence of the mathematical logical intelligence variable on student learning outcomes in linear algebra courses.

From the results that have been stated, it can be interpreted that mathematical logical intelligence has an influence of 53% on student learning outcomes in

linear algebra courses. This is in line with research conducted by Dafid et al. (2022) which gives the result that mathematical logical intelligence contributes to the improvement of student learning outcomes in Linear Algebra lectures. Milsan and Wewe (2018) obtained the result that there is a significant relationship between mathematical logical intelligence and student learning outcomes. Mujiani (2016) obtained the result that there is an influence between mathematical logical intelligence on student learning outcomes. With this research, it is hoped that educators will be able to apply learning models that can be adapted to mathematical logical intelligence in students, especially in linear algebra courses so that student learning outcomes are more optimal.

CONCLUSION

Based on the research results that have been described, it can be concluded that there is an influence between mathematical logical intelligence on student learning outcomes in Linear Algebra courses of 0.527 or 53%. It is hoped that further research can use this research as a reference, especially research related to mathematical logical intelligence on learning outcomes by adding several relevant variables.

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