International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 5, Issue 3, 2019 Special Edition: *Science, Applied Science, Teaching and Education*

The Effect of Spatial Intelligence and Mathematical Logic Intelligence on Students' Mathematics Achievement

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Abstract

This study aims at determining the effect of spatial intelligence and mathematical logic intelligence on students' mathematics achievement in material systems of two variable linear equations. This ex post facto research was conducted at class VIII of SMP 5 Kendari, Southeast Sulawesi, Indonesia. The sampling technique was done by a simple random technique. Of the 10 classes, VIII available, one class was randomly selected as a sample, namely class VIIIG. Data was analysed using simple linear regression to determine the effect of each variable on mathematics achievement and multiple regression to determine the joint effect of spatial intelligence and mathematical logic intelligence on student mathematics achievement. The research findings indicated that there was a significant effect of spatial intelligence and mathematical logic intelligence on students' mathematics achievement, both partially and jointly, with the regression equation model $\hat{Y} = 23, 755 + 0.527X_1$, with $r^2 = 0.654$, $\hat{Y} = 43,926 + 0.291X_2$ with $r^2 = 0.684$, and $\hat{Y} = 29.107 + 0.295X_1 + 0.181X_2$ with $R^2 = 0.791$.

Keywords: *Spatial Intelligence, Mathematical Logic Intelligence, Mathematic*

Introduction

In general, students' achievement is influenced by two factors, external and internal factors. One of the internal factors is intelligence. Intelligence is an expression of someone's thinking that can be used as a modality in learning. It is the ability to solve problems or create valuable products in society which focuses on the use of abilities in real situations (Hoerr, 2000). Another definition of intelligence is the ability to solve problems and produce product models as a consequence of a particular cultural or community atmosphere (Gardner, 2000). David Wechsler states that intelligence is the ability to act directed, think rationally, and deal with its environment effectively (Behr, Cherian, & Mwamwenda, 2013). Based on the definition above, it can be concluded that intelligence is a mental ability that involves the process of thinking rationally. Therefore, intelligence cannot be observed directly, but it can be concluded from various concrete actions which are manifestations of the process of rational thinking.

The level of intelligence can help someone to deal with various problems that arise in life. Intelligence exists when humans are born and can always be developed into adulthood. However, the development of intelligence will be greater if it is done as early as possible in the child's life, (Council, 2015)(Anderson, 1999), by giving stimulus to the five senses. A child is born with a certain level of intelligence that might be able to develop (Cartwright & Peterson, 2007) although those developments differ from each child; depending on the combination of one's genetic inheritance and living conditions in the environment (Gardner, 2000). This means that even though intelligence is inherited from family genetic factors, intelligence can develop according to the environment in which a person is located.

Intelligence is the ability of individuals to utilize potentials that exists in themselves in an effort to solve a problem or to adapt to their environment. Given the complexity of problems in life, special skills are needed by integrating various intelligences possessed so that problems can

be resolved based on content problems. Therefore, everyone has more than one intelligence depending on which type of intelligence is more dominant in them.

There are 8 types of intelligence (Gardner, 2000) which interact to form a unity that is ready to be used in self-development, in an effort to solve problems. The eight intelligences are 1) linguistic intelligence, 2) spatial intelligence, 3) mathematical logic intelligence, 4) kinesthetics intelligence, 5) musical intelligence, 6) interpersonal intelligence, 7) interpersonal intelligence, 8) naturalist intelligence. In this study, the intelligence is only focused on spatial intelligence and mathematical logic intelligence as the main studies in relation to student mathematics achievement.

Spatial Intelligence Spatial

Intelligence involves a person's ability to visualize images (imagined) or to create them in the form of two or three dimensions. Spatial intelligence is the ability to accurately see and observe the visual and spatial world. Visual means images, while spatial are things that related to space and place. Thus, spatial intelligence is a person's ability to understand more deeply the relationship between an object and space.

Spatial intelligence is one's ability to think in three dimensions (Taylor, 2013), as well as one's ability to know something through visual observation and mental imagination (Williams & Newton, 2009). In order to understand three-dimensional objects, the ability to think with images, shapes and lines is needed (PEHLİVAN & DURGUT, n.d.), so as to be able to produce, store, retrieve, and change well-structured visual images (Sternberg, 2000). From the opinions above, it can be concluded that spatial intelligence is a person's ability to know and think in three dimensions of spatial reasoning, mental image, image manipulation, graphic and artistic skills, and active imagination and visualizing concepts and relationships between concepts.

The concept of spatial thinking is quite interesting to discuss because many studies have found that various difficulties in understanding mathematical objects exist. Spatial thinking is a collection of cognitive skills which consists of combination of three elements, namely spatial concepts, representations, and reasoning processes. From the point of view of mathematics, spatial intelligence is very important to be improved because each student must try to develop their abilities and senses, which is useful in understanding relationships and traits in mathematics to solve mathematical problems as well as problems in everyday life.

The main emphasis in learning mathematics is to describe numbers, to construct geometric spaces, and to expand ideas about numbers and to construct geometric spaces (Kline, 1962). It shows that the characteristics of mathematics have abstract objects (Korn & Korn, 2000)(Jesseph, 2010) which is difficult to be understood. To anticipate it, mathematics needs to be visualized so that students can understand the material taught. To be able to visualize objects in mathematics, it requires an intelligence that must be possessed by students, in this case spatial intelligence. Spatial intelligence is the ability to understand the visual world accurately, to transform and to modify one's initial perceptions through visual observation and mental imagination and to re-create aspects of the visual experience, even without relevant physical stimuli. As such, students who have spatial intelligence are able to understand mathematical material better and consequently their mathematics achievement are greater. Several researches dealing with spatial intelligence (Höffler, 2010)(Gani, Safitri, & Mahyana, 2017)(Tosto et al., 2014)(Casey, Nuttall, Pezaris, & Benbow, 1995)(Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014), have conducted different studies but the results are relatively the same, which conclude that there is a significant correlation between spatial intelligence and learning achievement.

Mathematical Logic Intelligence

Logic intelligence is one type of intelligence possessed by humans related to numbers and logic. This intelligence involves skills in terms of processing or using numbers and logical thinking (Salam, Ibrahim, & Sukardjo, 2019) as well as skills in using logic or common sense, logical reasoning, especially in the fields of mathematics and science. Logical ability includes logically counting, measuring, and completing mathematical matters (Baum, Viens, & Slatin, 2005) and considering prepositions and hypotheses, and completing mathematical operations. Logical-mathematical intelligence includes the ability to analyze problems logically, ability to solve mathematical problems, especially problems in mathematical operations and the ability to investigate a problem according to scientific principles (Gardner, 2000). Thus, students who have mathematical logic intelligence tend to be able to think logically, to solve problems, to recognize quantity concepts, to solve cause and effect relationships needed to solve mathematical questions. Thus, mathematical logic intelligence can influence mathematic achievement. Researches that have been done in relation to mathematical logic intelligence are(Ormrod, Anderman, & Anderman, 2006)(Hecht, Torgesen, Wagner, & Rashotte, 2001)(Aiken Jr, 1971). They found that there was a positive and significant correlation between mathematical logic intelligence and learning achievement.

Research on intelligence, especially the correlation between intelligence and learning achievement is often done, because intelligence in essence is very important in education. However, intelligence is often only partially understood or not comprehensively understood by some teachers in classroom learning. In mathematics learning, intelligence in particular spatial intelligence and mathematical logic intelligence are closely related to the results of the research described earlier, however, some teachers pay less attention to the intelligence problems that the

students have in carrying out the learning process. As a result, students usually experience difficulties in achieving a maximum learning result.

One of the causes of students' difficulties in learning mathematics is abstract mathematical material, so students sometimes have difficulty in understanding the material taught. To anticipate it, mathematics needs to be visualized. Students need to develop the ability to think and reason logically, so they can understand the material taught. To be able to visualize mathematical objects and reason logically, intelligence must be possessed by students, in this case spatial intelligence and mathematical logic intelligence. A student who has high spatial intelligence and logic intelligence tends to have high creativity in solving a problem, doing calculations well, being able to think logically, and doing reasoning correctly. Thus, students are able to understand mathematical material well, which ultimately their achievement is also good. Based on the description above, it is necessary to conduct a study on the effect of spatial intelligence and mathematical logic intelligence on student mathematics achievement.

Objective

The main objective of this study was to determine the effect of spatial intelligence and mathematical logic intelligence on mathematical achievement. Specifically, this study aims at finding out: 1). The significant effect of spatial intelligence on student mathematics achievement; 2). The significant effect of mathematical logic intelligence on student mathematics achievement; 3). The significant effect of spatial intelligence and mathematical logic intelligence on students' mathematics achievement.

Materials and Method

Research design

This was an ex post facto research that investigated causal effect relationships that are not manipulated or treated by researchers (Nunes et al., 2007). It involved one independent variable (Y), namely mathematics achievement, and two dependent variables (X) namely spatial intelligence (X_1) and mathematical logic intelligence (X_2).

Population and samples

Population of this study was all eighth-grade students of SMPN 5 Kendari, Southeast Sulawesi, Indonesia, who were enrolled in the odd semester of the 2018/2019 academic year consisting of 10 parallel classes with 388 students. The sampling technique was done by simple random method, by doing randomization of the class. From the randomization process, it was obtained class $VIII_G$ as the sample with 32 total numbers of students.

Instruments and procedures

Capability competency is in the form of knowledge about systems of linear equations with two variables which includes compiling a model of linear with two variables, completing the system of two variable linear equations with substitution methods, completing the system of two variable linear equations with elimination methods, completing the system of linear equations variables with mixed methods, and complete the system of linear equations two variables related to daily life, using substitution methods, elimination methods, and mixed methods. Mathematics achievement is scores obtained by students as research subjects measured by using mathematics achievement tests.

In this study, the instrument used to measure mathematics achievement was compiled based on the curriculum used in school as a place of this study conducted, namely the 2013 curriculum in class VIII in the odd semester 2018/2019 academic year which was developed in the form of multiple choice questions with 4 (four) answer choices. Data for spatial intelligence referred to a score obtained by students in answering questions related to spatial intelligence including spatial relationships, visual memory, visual discrimination, visual motor integration, visual perceptual abilities, visual integration, visual closure, and figure-ground discrimination. The instrument used to measure spatial visual intelligence was a standard instrument adapted from "Spatial practice tests 1"(Oni, 2013) arranged in multiple choice form with 5 (five) alternative answers and only 1 (one) correct answer. The correct answer was given score 1 and the incorrect answer was given a score 0.

Data for mathematical logic intelligence referred to score obtained by students in answering mathematical logic intelligence tests including simple arithmetic, numerical series, analysing numerical problems logically, and simple logical concept. The instrument used to measure mathematical logic intelligence used multiple choice tests with 4 (four) alternative answers and there was only one correct answer. The correct answer was given score 1 and the incorrect answer was given a score 0.

The procedure of data collection was done by giving tests to the samples which was supervised by the teacher. The process of giving the tests was done separately. The first day was mathematics learning test, the second day was spatial intelligence test, and the third day was mathematical logic intelligence test.

Data analysis

Analysis was performed by using two models of analysis, namely descriptive analysis and inferential analysis. Descriptive analysis was used to determine the mean score, variance,

standard deviation, maximum and minimum values, and an overview based on each characteristic in the form of a frequency distribution table, while inferential analysis was used to test the research hypothesis, using simple linear regression analysis, and multiple regression analysis. Simple linear regression analysis was used to determine the effect of spatial intelligence on mathematics achievement and the effect of mathematical logic intelligence on mathematics achievement, while multiple regression analysis was used to determine the effect of spatial intelligence and mathematical logic on mathematics achievement.

Before processing inferential data, a prerequisite analysis test was carried out, namely data normality. Data normality test was carried out by using the Kolmogorv-Smirnov test.

Findings

Before processing data using regression analysis, a normality test was performed for the independent variable (Y). The results of testing the normality of the data using Kolmogorov-Smirnov test are presented in Table 1.

The results of normality test as presented in table 1 above showed that students' mathematics achievement (non-independent variables) was normally distributed, with a significant value = 0.096, greater than the value of $\alpha = 0.05$. It means that regression equation obtained using the least squares method can be used to predict mathematics achievement by using spatial intelligence, mathematical logic intelligence, and collectively, between spatial intelligence and mathematical logic intelligence.

Estimation of regression parameters using the data least squares method of the dependent variable must meet the normal assumptions, if normal assumptions are violated or not fulfilled, then the use of the regression equation obtained in predicting the dependent variable will be biased. Therefore, before determining the regression parameter value using the

least squares method, a prerequisite test for normal data is done so that the equations obtained can be used to estimate what is expected.

If normal data assumptions are not met, it is required to use nonparametric statistical analysis, or the sample used is enlarged, namely n> 3000, so that the use of the least squares method in estimating regression equations can be used.

Research Question 1: Is there a significant effect of spatial intelligence on students' mathematics achievement?**Hypothesis 1:** There is a significant effect of spatial intelligence on students' mathematics achievement. The results of the analysis as presented in Table 2 below showed that there was a significant effect of spatial intelligence on students' mathematics achievement indicated by the significant value = 0,000 (smaller than the value of $\alpha = 0.05$).

The effect of spatial intelligence on mathematics achievement is presented in Table 3.The results of the analysis in Table 3 above showed that spatial intelligence had a positive and significant effect on mathematics achievement, where the significant value was 0,000 (smaller than the value of $\alpha = 0.05$), with the regression equation model $\hat{Y} = 23.755 + 0.527\ X1$, with the value r2 = 0.654.

Research Question 2: Is there a significant effect of mathematical logic intelligence on students' mathematics achievement?**Hypothesis 2:** There is a significant effect of mathematical logic intelligence on student mathematics achievement. The results of the analysis as presented in table 4 showed that there was a significant effect of mathematical logic intelligence on students' mathematics achievement indicated by a significant value = 0,000 (smaller than value $\alpha = 0.05$).

The results of the analysis as presented in table 4 above show that there was a significant effect of mathematical logic intelligence on mathematics achievement with a significant value = 0,000 (smaller than the value of $\alpha = 0.05$).

The effect of mathematical logic intelligence on mathematics achievement is presented in Table 5.

The results of the analysis in Table 5 above showed that spatial intelligence had a positive and significant effect on mathematics achievement, where the significant value was 0,000 (smaller than the value of α = 0.05), with the regression equation model $\hat{Y}$ = 43,926 + 0.291 X1, with the value r2 = 0.684.

Research Question 3: Is there a significant effect between spatial intelligence and mathematical logic intelligence on students' mathematics achievement?**Hypothesis 3:** There is a significant effect of spatial intelligence and mathematical logic intelligence on students' mathematics achievement. The results of the analysis as presented in Table 6 showed that there was a significant effect of spatial intelligence and mathematical logic intelligence on students' mathematics achievement indicated by a significant value 0,000 (smaller than the value α = 0.05).

The effect of spatial intelligence and mathematical logic intelligence on mathematics achievement is presented in the Table 7.

The results of the analysis in Table 7 above explain that spatial intelligence and mathematical logic intelligence had a positive and significant effect on mathematics achievement with estimated equation models $\hat{Y}$ = 29.107 + 0.295 X1 + 0.181 X2, with R2 = 0.791.

Result and Discussion

This study revealed the effect of spatial intelligence and mathematical logic intelligence on mathematics achievement of students at SMPN 5 Kendari, Southeast Sulawesi, Indonesia.With the fulfillment of normal data assumptions, the regression equation obtained using the least squares method can be used to predict mathematics achievement by using spatial

intelligence, mathematical logic intelligence, and collectively between spatial intelligence and mathematical logic intelligence.

Estimation of regression parameters using the least squares method of the dependent variable must meet normal assumptions. If normal assumptions are violated or not met, the use of the regression equation obtained in predicting the dependent variable will be biased. Therefore, before determining the regression parameter value using the least squares method, a prerequisite test for normal data is done so that the equations obtained can be used to estimate what is expected.If normal assumptions of the data are not met, it is required to use nonparametric statistical analysis or the sample is enlarged (n > 3000), so the use of the least squares method in estimating the regression equation can be used.

The results of the analysis as presented in Table 2 above showed that there was a significant effect of spatial intelligence on mathematics achievement with a significant value 0,000 (smaller than the value $\alpha = 0.05$), with a value of $r^2 = 0.654$. It means that the diversity of values of students' mathematics achievement of 65.40% could be explained by spatial intelligence while 34.60% was explained by other factors. This finding is the answer to the first problem which states that there is a significant effect of spatial intelligence on students' mathematics achievement. The existence of a positive and significant effect of spatial intelligence indicates that students tend to be able to create their imagination in the form of images in imagining a problem, then to apply it in real world to solve those problems based on their potential. This finding is in line with the results of research conducted by(Newton & Bristoll, 2009)(Setyawan, 2018)(Wenas & Sambuaga, 2017). They concluded that there was a positive and significant effect of visual-spatial intelligence on students' mathematics achievement.

Results of the analysis in Table 3 showed that spatial intelligence had a positive and significant effect on mathematics achievement with significant value 0,000 (is smaller than the

value of $\alpha = 0.05$), with the regression equation model $Y\hat{} = 23.755 + 0.527\ X_1$. The regression equation means that the direction of the regression equation has a positive sign so that it can be concluded that spatial intelligence has a positive effect on mathematics achievement. Change in the value of spatial intelligence by one unit increases mathematics achievement by 0.527.Analysis for the effect of mathematical logic intelligence on students' mathematics achievement was carried out using linear regression analysis.

Results of the analysis as presented in Table 4 showed that there was a significant effect of mathematical logic intelligence on mathematics achievement with a significant value 0.000 (smaller than the value of $\alpha = 0.05$), with a value of $r^2 = 0.684$. Score r2 indicates that the variety of students' score 68.40% could be explained by mathematical logic intelligence while 31.60% was explained by other factors. This finding is an answer to the second problem which states that there is a significant effect of mathematical logic intelligence on students' mathematics achievement. This finding is in line with the results of research conducted by (PEHLİVAN & DURGUT, n.d.)(Hawes, Moss, Caswell, Seo, & Ansari, 2019)(Sahay, 2019) which concluded that there was a positive and significant effect of mathematics logic intelligence on the achievement of financial accounting courses and mathematics achievement.

The results of the analysis in Table 5 showed that mathematical logic intelligence had a positive and significant effect on mathematics achievement with the significant value 0,000 (smaller than the value of $\alpha = 0.05$), with the regression equation model $Y\hat{} = 43{,}926 + 0.291\ X_2$. The regression equation indicates that the direction coefficient of the regression equation was positive so that it can be concluded that mathematical logic intelligence had a positive effect on mathematics achievement. Change in the value of mathematical logic intelligence by one unit increases mathematics achievement by 0.291.

The joint effect between spatial intelligence and mathematical logic intelligence on students' mathematics achievement was analysed by using multiple regression analysis. The results of the analysis are presented in table 6 showed that spatial intelligence and mathematical logic intelligence simultaneously had a significant effect on mathematics achievement with a value of R^2 = 0.791. it indicates that 79.10% of the diversity of students' mathematics achievement was influenced by spatial intelligence and mathematical logic intelligence, while the remaining 20.90% was influenced by other factors. This finding answers the third problem which states that there is a significant effect of spatial intelligence and mathematical logic intelligence on students' mathematics achievement. It is in line with the results of research (Mix, 2019)(Kafanabo, 2018) which concluded that spatial intelligence and mathematical logic intelligence had positive and significant effect on student mathematics achievement simultaneously.

The joint effect between spatial intelligence and mathematical logic intelligence on mathematics achievement is presented in table 7. The results obtained showed that spatial intelligence and mathematical logic intelligence had a positive and significant effect on mathematics achievement with the equation model $(Y.)\hat{} = 29{,}107 + 0.295\ X_1 + 0.181\ X_2$. It means that if mathematical logic intelligence is constant, the change in the value of spatial intelligence by one unit increase mathematics achievement by 0.295. Vice versa, if the value of spatial intelligence is constant, the change in the value of mathematical logic intelligence by one-unit increased mathematics achievement by 0.181. The value of the coefficient of determination was R2 = 0.791, which implies that 79.10% of the students' mathematics achievement was influenced by spatial intelligence and mathematical logic intelligence, the remaining 20.90% was influenced by other factors.

Conclusion

Based on the findings and discussion of this study, it can be concluded that: 1). Spatial intelligence had a positive and significant effect on students' mathematics achievement, with the regression equation model $Y\hat{} = 23.755 + 0.527\ X_1$; 2). Change in the value of spatial intelligence by one unit increased students' mathematics achievement by 0.527; 3). Coefficient of determination was $r^2 = 0.654$ which implies that 65.40% of the perceived value of mathematics achievement can be explained by the value of spatial intelligence, while the remaining 34.60% was explained by other factors; 4). Mathematical logic intelligence had a positive and significant effect on students' mathematics achievement, with the regression equation model$Y\hat{} = 43{,}926+ 0.291\ X_2$; 5). Change in the value of mathematical logic intelligence by one unit increased students' mathematics by 0.291; 6). Coefficient of determination was $r^2 = 0.684$ which implies that 68.40% of the mathematic achievement could be explained by the value of mathematical logic intelligence, while the remaining 31.60% was explained by other factors; 7). Spatial intelligence and mathematical logic intelligence had a positive and significant effect on students' mathematics achievement, with the regression equation model $Y\hat{} = 29.107 + 0.295\ X_1 + 0.181\ X_2$; 8).If the value of mathematical logic intelligence was constant, then the change in the value of spatial intelligence by one unit increased students' mathematics achievement by 0.295. If the value of spatial intelligence was constant, the change in the value of mathematical logic intelligence by one unit increased students' mathematics achievement by 0.181; 9). Coefficient of determination was $R^2 = 0.791$ which implies that 71.10% of the perceived value of mathematics achievement could be explained by the value of spatial intelligence and mathematical logic intelligence, while the remaining 20.90% was explained by other factors.

Table 1. Results of normality test

Data Group	Statistik	Y
N		32
Normal parameters	Man	63.3438
	Std. Deviation	5.32559
Most Extreme Differences	Absolute	0.143
	Positive	0.105
	Negative	-0.143
Test Statistic		0.143
Asymp Sig. (2-tailed)		0.096

Table 2. Results of variance analysis (ANOVA) on the effect of spatial intelligence on mathematics achievement

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	575.257	1	575.257	56.776	.000
Residual	303.962	30	10.132		
Total	879.219	31			

Table 3. Results of regression analysis on the effect of spatial intelligence on mathematics achievement

Model	R Square	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		

Constant	.654	23.755	5.284		4.496	0.000
X_1		0.527	0.070	0.809	7.535	0.000

Table 4. Results of variance analysis (ANOVA) on the effect of mathematical logic intelligence on mathematics achievement

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	601.794	1	601.794	65.076	.000
Residual	277.425	30	9.247		
Total	879.219	31			

Table 5. Results of regression analysis on the effect of mathematical logic of intelligence on mathematics achievement

Model	R Square	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
Constant	0.684	43.926	2.466		17.810	0.000
X_2		0.291	0.036	0.827	8.067	0.000

Table 6. Results of variance analysis (ANOVA) on the effect of spatial intelligence and mathematical logic intelligence on mathematics achievement

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	695.823	2	347.912	55.015	0.000
Residual	183.395	29	6.324		
Total	879.219	31			

Table 7. Results of regression analysis on the effect of spatial intelligence and mathematical logic intelligence on mathematics achievement

Model	R Square	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
Constant		29.107	4.351		6.690	0.000
X_1	0.791	0.295	0.077	0.453	3.856	0.001
X_2		0.181	0.041	0.513	4.366	0.000

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