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The Effect of Discovery Learning Model Assisted Based Geogebra on Mathematical Critical Thinking Abilities of High School Students

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Abstract: This research aims to ascertain the impact of the discovery learning model assisted by geogebra software on the mathematical critical thinking abilities of first grade high school students at one of the public schools in eastern Jakarta in the school year 2023/2024. This study employs experimental research methodologies in a quantitative manner. Using a posttest-only control design and cluster random sampling as the sampling technique, the researcher implemented this research design. Class XA served as the experimental class and class X-C served as the control class for the samples that were chosen. A posttest in the form of a description test is the method utilized to collect data. This research uses data analysis techniques, namely testing the prerequisites for normality and homogeneity, hypothesis testing in the form of the t test and effect size test. From the t test data, the significance is 0,13 and the effect size test on the point estimate is 0,603, meaning that there is a large influence of the discovery learning model assisted by geogebra software at a medium level on critical mathematical thinking abilities.

Keywords: *Discovery Learning; Geogebra Software; Mathematical Critical Thinking Ability.*

INTRODUCTION

Learning is an interactive reaction between students, teachers, and learning resources that runs optimally in achieving learning goals (Tanjung et al., 2023). In mathematics learning activities there is a series of teaching that aims to develop understanding, abilities, and positive attitudes towards mathematics (Marasabessy et al., 2021). Thus, it may be said that teaching and learning activities include many teaching strategies and methods designed to facilitate the process of understanding and mastering mathematical concepts. So that teachers expect that each individual who participates in mathematics learning is able to interpret mathematical concepts, apply them in various contexts, and develop critical and analytical thinking abilities.

Learning activities in mathematics should ideally be able to raise pupils' critical thinking abilities, particularly in the area of mathematical reasoning. According to Faridah & Nasikhah (2019), mathematical critical thinking ability is the ability to reason skillfully and logically in considering and evaluating a problem and is important for making decisions. Based on the previous definition, it is stated that critical thinking ability is an intelligent and logical thinking abilities that involves understanding, consideration, evaluation, and analysis of mathematical problems with the aim of applying it to various mathematical topics. This is in accordance with the objectives of learning mathematics in the independent curriculum according to the Education Curriculum and Assessment Standards Agency (2022) "which is able to provide" stimulus to students to connect, solve, and apply mathematical ideas or concepts to material in the form of symbols, patterns, diagrams or other media.

The importance of a mathematical thinking ability according to Angraini & Wahyuni (2021) in the learning process is as a means for students to solve mathematical problems at a high level, it corresponds to one of the educational goals. The benefits of mathematical critical thinking abilities are that students become interactive in participating in a series of mathematics teaching and learning activities and teachers will play a role in mediating, facilitating, and providing motivation to support students in learning. Karim & Normaya (2015) revealed that there are 4 indicators that can be seen in critical thinking abilities, namely: 1) Interpretation or interpreting the specified problem, 2) Analyze or identify the relationship between statements, questions, and concepts in the problem, 3) Evaluate or appropriate strategies in solving problems, 4) Inference or conclude appropriately.

In fact, in the results of the Program for International Student Assessment (PISA) in 2022, Indonesia's average mathematics score was 366 from the OECD average score of 472 with a rank of 69 out of 80 countries (OECD, 2022). From these results, it can be assessed that Indonesia's average math score is smaller than the OECD average score. This information is also reinforced by data from the end of semester one assessment conducted at one of the public schools in eastern Jakarta with an average range of 43,5 – 52,5 from the total number of X classes, which is 6 classes. Based on these two results, it can be stated that students in Indonesia tend to have weaknesses in critical thinking abilities when facing math problems.

The low students' capacity for critical thought can be caused when in mathematics learning activities students are less involved so that learning is dominated by the teacher not on the understanding of students (Serin, 2023). Because students are more active in listening, so that when the teacher gives HOTS exercises in the form of stories, they find it difficult to interpret and solve mathematical problems in the exercise problems (Anggraini et al., 2022). Therefore, students do not have adequate training in acquiring critical thinking abilities when involved in mathematics learning that utilizes this model.

Applying a mathematics learning model such as discovery learning can encourage the growth of critical thinking abilities in the mathematics domain. Discovery learning is a series of learning activities that require students to be able to develop mathematical concepts independently or discover new concepts and information, and not be directly introduced to these mathematical concepts by the teacher (Istiqomah et al., 2021). According to Sawah & Kusaka (2023), one benefit of the Discovery Learning paradigm is that it might inspire students to locate and analyze mathematics problems in a more capable, creative, and participatory way. It is possible to conclude that the Discovery Learning approach can help address pupils' poor critical thinking abilities based on these two definitions.

The discovery learning model there are 6 steps, including: 1) providing a stimulus at the beginning of learning can use several questions or that lead to preparation so that students are encouraged to be active during learning, 2) identifying problems that must be solved by finding new or existing concepts through guidance by the teacher in the form of hypotheses or temporary answers, 3) collecting appropriate data or information so that hypotheses can be true, 4) process data or information by conducting group discussions or asking the teacher, 5) carry out precise proof by connecting the hypothesis with the data that has been processed and explaining it to the teacher or other group friends, 6) draw conclusions or strengthen the results that have been obtained (Prasetyo & Abduh, 2021; Sapilin et al., 2019).

From the explanation above, it is interpreted that the discovery learning model is a series of activities of teachers and students to achieve learning goals that include capable students in the process through 6 (six) stages, these being: 1) Stimulation or stimulus provision; 2) Problem statement; 3) Data gathering; 4) Data processing; 5) Verification; and 6) conclusion.

To conduct effective mathematics learning, teachers can utilize software or applications as support in an effort to improve students' abilities, especially in their critical thinking (Mollakuqe et al., 2021). geogebra software is one of the software that is useful for supporting the context of teaching mathematics by visualizing mathematical concepts and helping students understand in a realistic way (Fathurrahman & Fitrah, 2023; Karakuş et al., 2022). Therefore, in the discovery learning model, teachers can utilize learning media in the form of geogebra software to foster students' critical thinking abilities in understanding mathematical concepts visually and in developing students' activeness in every series of teaching and learning activities.

Therefore, using this framework and the previously described discussion as a basis, researchers will investigate how the discovery learning model, in conjunction with geogebra software, enhances the mathematical critical thinking abilities of first grade high school students at one of the public schools in eastern Jakarta in the school year 2023/2024.

METHODOLOGY

Based on the formulation of the research that has been outlined, This study's objective is to ascertain how the critical mathematical thinking ability of students at one of the public schools in the East Jakarta area is influenced by the learning model of geogebra-aided discovery. The research is scheduled for the full semester of the academic year 2023/2024, which will take place in March with class X becoming the research population.

For this research, the researchers adopted the Cluster Random Sampling method. Then from the entire population a vote was made and two classes were selected: XA (experimental class) and XC (control class) to be sampled with a total of 36 pupils each. The research is scheduled to follow the instructions of the school.

The quantitative approach is the approach set by researchers in this study. The methodology of the study is experimental research. To observe the treatment's effects, researchers will administer a treatment. In this study, the researcher adopted a Posttest Only Control design which involves measurement after treatment in two groups (control group and experimental group). This design model is described as follows:

$$\begin{array}{ccc} \boldsymbol{R_1} & \boldsymbol{X} & \boldsymbol{O_1} \\ \hline \boldsymbol{R_2} & & \boldsymbol{O_2} \end{array}$$

Table 1. Presents the design of research carried out by the researcher according to the methodology.

Tabel 1. Treatment Design Posttest Only Control Design

Group	Treatment	*Posttest*
Experimental ($\boldsymbol{R_1}$)	Conducting discovery learning model treatment assisted by geogebra software	O_1
Control ($\boldsymbol{R_2}$)	No treatment of discovery learning model assisted by geogebra software	O_2

Description:

O_1 : Experimental group posttest
O_2 : Control group posttest
X : Treatment

The treatment design carried out by researchers from the independent variable (X) to the dependent variable (Y) can be measured from the posttest results in the form of a description test which before being tested will go through the validity and reliability test stages.

The Pearson's product moment formula in Excel, which calculates correlation coefficients, is used in the validity test. The dependability coefficient value was then used by the researchers to calculate the instrument's reliability using the Alpha formula. The posttest can be administered to the sample to gauge the degree of influence gained once it has been deemed valid and reliable (Shara et al., 2022). If the posttest score obtained by students is significantly greater, it implies that pupils are impacted by the care they receive. In this study, researchers conducted data analysis techniques through normality tests, homogeneity tests and effect size tests using SPSS.

RESULT AND DISCUSSION

Pre-requisite Test 1 (Normality Test)

One of the prerequisites for determining whether or not the data in this study was normally distributed was to conduct a normality test. In this study with a sample size of 36 students in each class (n < 50), using the Shapiro-Wilk calculation findings found on SPSS, the normalcy test was performed (Setyawan, 2019).

Table 2. Tests of Normality

		Shapiro-Wilk		
Critical Thinking Abilities	**Class**	**Statistic**	**df**	**Sig.**
	Experimental	.968	36	.380
	Control	.961	36	.237

Table 2. With a degree of freedom (df) of 36, the experimental group has a value of 0.380 with statistical significance. For the control group, the value of 0.237 exceeds the predetermined level of significance 0.05. Therefore, it can be inferred that both sets of data are derived from populations that exhibit a normal distribution.

Pre-requisite Test 2 (Homogeneity Test)

Prior to performing data analysis if the significance value is > 0.05 it can be said that the variance of two or more data distributions is homogeneous. The homogeneity test for this investigation can be observed in the Levene's Test of Equality computation results.

Table 3. Homogeneity Test

		Levene Statistic	**df1**	**df2**	**Sig.**
Critical Thinking Abilities	Based on Mean	.145	1	70	.705
	Based on Median	.144	1	70	.706
	Based on Median and with adjusted df	.144	1	69.814	.706
	Based on trimmed mean	.139	1	70	.710

a. Dependent variable: Critical Thinking Abilities
b. Design: Intercept + Class

Table 3. The two data distributions show a homogeneous variance, as shown by the significance value given on the base on mean of 0.705 > 0.05.

Hypothesis Testing

The t-test is carried out by researchers as one of the hypothesis tests that aims to make comparisons in two groups that are not paired with each other or two different sample groups to be studied by researchers. The test categories are:

H_0 : The experimental class and the control class do not differ in the pupils' capacity for mathematical critical thinking.

H_1 : The experimental class and the control class's mathematical critical thinking abilities differ from one another.

If the significance of the t-test < 0.05 then H_0 is rejected, indicating that students' capacity for mathematical critical thinking differs across the experimental and control groups (Simsek, 2023).

Table 4. Descriptive Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Critical Thinking Abilities	Experimental	36	45.6667	17.37979	2.89663
	Control	36	35.0556	17.82125	2.97021

Table 5. The T-Test

		F	Sig.	t	df	Sig. (2-tailed)
Critical Thiking Abilities	Equal variances assumed	.145	.705	2.558	70	.013
	Equal variances not assumed			2.558	69.956	.013

Based on table 4. descriptive statistics, the average (Mean) of the second class posttest after treatment was 45.6667 for the experimental group and 35.0556 for the control group, with an average difference of 10.6111 for the two classes. It shows indicating the experimental group's average is greater than the control group's average after using the learning model of discovery with the help of geogebra software. Then in table 5. for the t test, because the data is homogeneous or equal variance then the result of the calculation of significance is seen on the equal part variances assumed with its homogenous significance of 0.705 or sig > 0.05 (homogen).

So we get a t-test significance or sig. (2-tailed) of 0.013. In light of the preceding theory, consequently, it may be said that sig < 0.05 means that the student's ability to think critically mathematically differs between the experimental group and the control group (H_0 is rejected).

Effect Size Test (Cohen's d)

The effect size test in this study was measured from the results of the calculation of Cohen's d aims to measure how much influence the treatment (treatment) of the average difference between the two groups that have been obtained in the t-test data analysis technique. The greater the effect size obtained, the greater the influence obtained. The following is a table of effect size test criteria (Cohen, 1988; Sawilowsky, 2009).

Table 6. Effect Size Criteria

***Effect Size* (ES)**	***Interpretation***
0,00 ≤ ES < 0,20	*Ignored*
0,20 ≤ ES < 0,50	*Small*
0,50 ≤ ES < 0,80	*Medium*
0,80 ≤ ES < 1,20	*Large*
1,20 ≤ ES	*Very Large*

After conducting the effect size test, the following table of results can be analyzed:

Table 7. Effect Sizes Test

				95% Confidence Interval	
		Standardizer[a]	Point Estimate	Lower	Upper
Critical Thinking Abilities	Cohen's d	17.60190	.603	.128	1.073
	Hedges' correction	17.79334	.596	.127	1.062
	Glass's delta	17.82125	.595	.109	1.074

The point estimate was determined to be 0.603 based on the Cohen's d effect size test computation findings. If these results are adjusted to the effect size criteria table, it means that the point estimate of 0.603 is in the medium range ($0.50 \leq ES < 0.80$). So The results indicate that high school students, particularly those in experimental class and control class, had a modest to medium impact on their mathematical critical thinking abilities when using the discovery learning model with the help of geogebra software.

The research was conducted for four weeks in March. The geogebra-aided discovery learning model is used in experimental classes and conventional models are used in control classes. The study ended with an eight-digit posttest description of the square function material to measure whether the discovery learning model affects the student's abilities. Before the posttest was distributed to the experimental and control class, the Posttest had been tested for validity and reliability to expert validators and student validators at one of the high schools in the district.

Examine the validity of the instrument by comparing the answers to the eight question values that are considered valid using Pearson's product moment in excel. The degree of validity of the instrument is $0.6 \leq r_{xy} \leq 0.8$ with the interpretation of validity said to be high. Instrument reliability test using Croanbach alpha in excel with the results of 8 question numbers amounting to 0.91, it can be said that the level of reliability is very high. So that the instrument 8 number of questions is suitable for use as a measure of the level of mathematical critical thinking ability in experimental group and control group.

The results obtained from the posttest will then be processed using SPSS through the normality test phases, homogenity test, t test, and effect size. With the number of samples in each class of 36 ($\leq$ 50), the results of Shapiro Wilk are used in the normality test of this study. Based on the normality results described above, for the experimental group the significance value was $0.380 > 0.05$ and for the control class the significant value was $0.07 > 0.05$. So, this indicates that the data is distributed normally.

The homogeneity test is seen from Levene's Test of Equality calculations. The result is obtained that the significance value is $0.705 > 0.05$ on based on mean. It can be concluded that the two distributions of the data are homogeneous or identical. Once the data is distributed in normal and homogenous variations, then do the t test to see if the treatment of the geogebra-aided discovery learning model on the matter of square functions has a significant influence.

The results contained in the descriptive statistical table obtained an average (Mean) of the second class posttest after given treatment, with an average score of 45.6667 for the experimental group and 35.0556 for the control group. The average difference between the two was 10.6111 showing that the critical mathematical thinking ability of class X students has been improved after applying the discovery learning model with the help of geogebra. Subsequently, the significance of the t test of 0.013 was found, Drawing from the preceding premise, it may be inferred that sig < 0.05 means the student's ability to think critically mathematically between the two classes is different (H_0 is rejected).

Considering the outcomes of the effect size computation test on Cohen's d, it is obtained that the point estimate is 0.603. If the result is adjusted with the table of effect size criteria, then the point assessment of 0.603 is in the medium range ($0.50 \leq ES < 0.80$). The results showed that there was a moderate level of influence, since the use of new geogebra was first used by pupils, requiring prior introduction at the beginning of learning.

CONCLUSION

It may be inferred from the findings and earlier talks that the discovery learning model with the use of Geogebra software has a significant influence on the ability at one of the public schools in eastern Jakarta in critical mathematical thinking in experimental class. The influence of the model of discovery Learning assisted with geogetra software on critical thinking mathematics is at a medium/medium level, because the use of new geogebra software was first used by them so that students require prior introduction at the beginning of learning. It may be inferred from the findings and earlier talks that the discovery learning model with the use of Geogebra software has a significant influence on the ability at one of the public schools in eastern Jakarta in critical mathematical thinking in experimental class. The influence of the model of discovery Learning assisted with geogetra software on critical thinking mathematics is at a medium/medium level, because the use of new geogebra software was first used by them so that students require prior introduction at the beginning of learning.

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(Need for two or more authors)
Ayu Setyawati: Conceptualization, design, analysis, writing.
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(Each author must have contributed to at least one aspect of each of these criteria: concept and design, data acquisition, data analysis / interpretation, drafting manuscript, critical revision of manuscript, statistical analysis, securing funding, admin, technical or material support, supervision, final approval.)

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