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Improving Students' Creative Thinking Skills Assisted by GeoGebra Software

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Abstract

This study aims to improve students' creative thinking skills in problem-based, ill-structured, open-ended learning through stimulus. This study used learning strategies that simultaneously develop problem-solving strategies and knowledge discipline. This learning can be achieved if educational activities are focused on authentic, contextual, and relevant tasks or problems so that students can gather the necessary information, evaluate alternative solutions, and present solutions they believe in. Moreover, the ability to generate uncommon or extraordinary ideas must be raised from the problems that exist in learning. The ability to think creatively in mathematics in education using the Problem-Based Learning (PBL) approach assisted by GeoGebra is expected to be a practical approach to educating students in increasing their intellectual potential and familiarizing them to deal with non-routine problems and applying it in their daily life to become a student who can think creatively. This study used a quasi-experimental research method with a quantitative approach conducted at SMA Negeri 2 Cimalaka. The instruments used in this study were questionnaires and tests. This study's approach, which was integrated with GeoGebra, can be used as an alternative to learning mathematics in schools. It can be developed with other approaches according to problems in mathematics.

INTRODUCTION

Many students have a terrible perception of mathematics because few can explore and understand it as a science that can train creative thinking skills (Al Ayyubi et al., 2023). Many learning methods are carried out, but, generally, students' activities only focus on mathematical activities in solving problems with one solution and ending with giving exercises to solve independently. These learning activities are referred to as rote learning, which is a learning activity that only makes students tend to memorize without comprehending or understanding what is being taught, while educators are often unaware of it, so the students find it difficult to understand mathematics (Mulyono & Hapizah, 2018; Sari et al., 2022). It turns out that the difficulty in understanding mathematics is thought to be related to teaching methods that do not make students feel stimulated and sympathetic to mathematics (Harefa et al., 2020). Moreover, the approach is generally less varied and monotonous (Fatimah & Puspaningtyas, 2022).

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There are some characteristics of learning strategy based on the view of constructivism. These are involving students in the learning process, implementing the discussions in small groups in a more significant portion, presenting the abstract concepts to be more concrete, presenting non-routine problems to arouse curiosity and optimization in thinking power, and having more time used to expand understanding and other higher-level thinking abilities (Saidah, 2021; Sofiah et al., 2020). One approach to learning mathematics based on the view of constructivism is Problem-Based Learning (PBL) (Setiyaningsih & Subrata, 2023). In its process, this kind of learning presents a learning environment with problems as its basis, and this can be connected with visualization through GeoGebra to support learning (Sugandi et al., 2019).

One of the things that can be done to improve students' creative thinking skills is to use mathematics learning techniques, methods, and approaches that require students to master the materials without focusing on the teacher (Al Ayyubi et al., 2018). It should emphasize a student-centered approach (Bukhari. The dominance of the students experiencing difficulties in applying mathematics in their daily lives is due to learning mathematics, which is only used as a place to apply concepts and not as a base to start learning. Another thing that causes mathematics difficulty for students is that mathematics is perceived as a less meaningful lesson (Fitrah & Kusnadi, 2022; Ilmiyah et al., 2018; Nisa et al., 2022). The context of daily life as an experience or prior knowledge that the students have owned is rarely associated with learning in the classroom (Al Ayyubi et al., 2024; Al Ayyubi et al., 2024; Al Ayyubi et al., 2024). In addition, teachers do not provide opportunities for the students to reinvent and construct their mathematical ideas (Pancawardana et al., 2023; Sabarudin et al. et al., 2023; Sabarudin et al. et al., 2023). Then, one of the reasons why the students are weak in mathematics is because they cannot understand or recognize basic mathematical concepts related to the topic being discussed (Ati & Setiawan, 2020; Khikmiyah, 2021; Sukmawarti et al., 2022).

From the descriptions above, it can be seen that there is a coherence in the ability to think creatively in mathematics in learning using the Problem-Based Learning (PBL) approach assisted by GeoGebra. This approach is expected to effectively educate students to increase their intellectual potential, familiarize them with non-routine problems, and apply them daily. It is expected that this approach integrated with GeoGebra can be used as an alternative in learning mathematics in schools and can be developed with other approaches according to problems in mathematics because GeoGebra can provide visualization to students to be expanded concretely and activate the power of students' abstraction in analyzing inherent conclusions.

METHOD

This study used a quasi-experiment research method with a quantitative approach conducted at SMA Negeri 2 Cimalaka. The instruments used in this study were questionnaires and tests. The test used in this study is a written test in the form of an essay that has been tested for validity, reliability, discrimination power, and difficulty index.

The population of this study was students' X grade at SMA Negeri 2 Cimalaka with a sample of 30 students in the experimental class and 31 students in the control class on Trigonometry material. The data analysis test used the normality test using Kolmogorov-Smirnov, which was assisted by SPSS software version 26. Tests on independent samples were carried out on two pieces of data from different individual samples to be compared. Independent t-test assumptions must be met, including containing interval or ratio data scales, unpaired data groups, and data groups that must be normally distributed. So, if the data assumption of normality is not met, non-parametric statistics should be used, namely by testing the Mann-Whitney U Test.

RESULTS

The results of learning using the Problem-Based Learning approach assisted by GeoGebra as an experimental and control class are presented in the following descriptive statistics.

Table 1. Descriptive Data Output of Experimental Class and Control Class

Data Statistik	Experimental Class			Control Class		
	Pretest	Postest	N-Gain	Pretest	Postest	N-Gain
Mean	74.77	77.67	0.2013	64.74	68.77	0.1006
Standard Deviation	3.411	3.044	0.1124	4.404	4.364	0.1765
Minimum	71	71	0.00	55	61	-0.36
Maximum	85	89	0.45	75	77	0.35

Based on Table 1 above, the statistical data for the experimental class is greater than that of the control class. It has not answered the research hypothesis yet, so the inferential statistical tests are carried out as follows.

Table 2. Output of Pre-test Data Normality Test

Class		Kolmogorov-Smirnov[a]		
		Statistic	Df	Sig.
Value	Experimental	.173	30	.023
	Control	.265	31	.000

Based on Table 2 above, the significance values for the experimental and control classes are 0.023 and 0.000. This indicates that the significance value is smaller than 0.05. It can be concluded that the pre-test data is not normally distributed.

Table 3. Output of Pre-test Data Homogeneity Test

Levene Statistic	df1	df2	Sig.
0.370	1	59	.545

Based on Table 3 above, the significance value of the student's learning outcomes is 0.545 or greater than 0.05. This indicates that the data variance of the two classes is homogeneous.

Table 4. Output of Mean Rank

	Class	N	Mean Rank
Learning Outcomes	Experimental	30	45.93
	Control	31	16.55

Based on Table 4 above, it was found that the mean rank value for the experimental class is greater than that of the control class, but this result needs to be proven for its significance.

Table 5. Output Mann-Whitney

	Hasil Belajar
Mann-Whitney U	17.000
Wilcoxon W	513.000
Z	-6.542
Asymp. Sig. (2-tailed)	.000

Based on Table 5 above, it is obtained that the Asymp. Sig. (2-tailed) is 0.000 or smaller than 0.05 so that based on the decision criteria, H_0 is rejected. It can be concluded that there is a difference in the average of the student's initial ability in the experimental and control classes.

Table 6. Output of Post-test Data Normality Test

Class		Kolmogorov-Smirnov[a]		
		Statistic	Df	Sig.
Value	Experimental	.103	30	.200*
	Control	.109	31	.200*

Based on Table 6 above, the significance value for the experimental and control classes is 0.200. From this data, it is obtained that the significance value is more significant than 0.05. It can be concluded that the post-test data is usually distributed.

Table 7. Output of Post-test Data Homogeneity Test

Levene Statistic	df1	df2	Sig.
4.209	1	59	.0,45

Based on Table 7 above, it is obtained that the significance value of the student's learning outcomes is 0.045 or smaller than 0.05. This indicates that the data variance of the two classes is not homogenous.

Table 8. Output of Mean Equality Test of Post-test Data

		t-test for Equality of Means		
		t	df	Sig. (2-tailed)
Value	Equal variances assumed	9.202	59	.000
	Equal variances not assumed	9.255	53.701	.000

Based on Table eight above, it is obtained that the Asymp. Sig. (2-tailed) is 0.000 or smaller than 0.05. This indicates that the average value of the final students' creative thinking skills in the experimental class is significantly better than the control class's average. Next, in order to find out whether the improvement in learning outcomes is meaningful or not, the N-Gain test was conducted.

Table 9. Output of N-Gain Data Normality Test

Class		Kolmogorov-Smirnov[a]		
		Statistic	Df	Sig.
Value	Experimental	.109	30	.200*
	Control	.104	31	.200*

Based on Table 9 above, the significance value for the experimental and control classes is 0.200. From this data, it is obtained that the significance value is more significant than 0.05. It can be concluded that the post-test data is usually distributed.

Table 10. Output of N-Gain Data Homogeneity Test

Levene Statistic	df1	df2	Sig.
5.546	1	59	.0,022

Based on Table 10 above, it is obtained that the significance value of the student's learning outcomes is 0.022 or smaller than 0.05. This indicates that the data variance of the two classes is not homogeneous.

Table 11. Output of Mean Equality Test of N-Gain Data

		t-test for Equality of Means		
		T	Df	Sig. (2-tailed)
Value	Equal variances assumed	2.648	59	.010
	Equal variances not assumed	2.667	51.132	.010

Based on Table 11 above, it is obtained that the Asymp. Sig. (2-tailed) is 0.010 or smaller than 0.05. This indicates that improving students' creative thinking skills in the experimental class is better than in the control class.

Table 12. Output of Effect Size Test

	Effect Size	Standard Deviation	Interpretation
Creative Thinking	4,65	3.64	Very high

Based on Table 12 above, it is obtained that the Effect Size value is 4.65, which is included in a very high category. This indicates that the problem-based learning (PBL) approach dramatically affects students' creative thinking skills when integrated with GeoGebra software.

DISCUSSION

Essential characteristics of creative thinking, according to Manurung et al. (2020), are (1) fluency is the ability to build ideas quickly, without significant obstacles; (2) flexibility refers to the ability to change solution ideas so that they can become more diverse or in other words, in problem-solving, flexibility is related to the ability to try various approaches in solving a problem; (3) originality or novelty is the ability to generate uncommon or extraordinary ideas, solve problems in an uncommon or non-standard wayor use something or utilize a situation uncommonly; (4) elaboration is the resultof various implications; and (5) problem Sensitivity is the ability to recognize the existence of a problem or ignore misleading facts to recognize the real problem. In general, the ability to think creatively is related to the ability to produce or develop something new, based on inquiry and invention, unusual and different from the ideas produced by most people (Ulandari et al., 2019). In principle, the various views on the meaning and components of creativity can be said to be entirely in line, but the way of expressing these opinions is often different. In principle, the various views on the meaning and components of creativity can be said to be entirely in line, but the way of expressing these opinions is often different.

To become a student who can think creatively, according to Panjaitan & Surya (2017), various stages must be passed, which include (1) problem orientation, formulating the problem and identifying aspects of the problem; (2) preparation, where the mind must get as much information as possible that is relevant tothe problem; (3) incubation, when the problem-solving process reaches a dead end, let the mind rest for a moment; (4) illumination, where the thinker begins to get inspiration and a series of insights that are considered to solve the problem; and (5) verification, the thinker must test and critically assess the solution proposed at the illumination stage. If it turns out that the proposed method cannot solve the problem, it is better to go back through the five stages to find a new, more appropriate solution.

Problem-Based Learning is based on the philosophy of human-focused, community-oriented education through an interdisciplinary approach. Learning based on a problem is a constructive cognitive activity because, based on the view of cognitive psychology, learning is a process of constructing new knowledge based on the knowledge that has been owned. This illustrates that Problem-Based Learning is developed based on educational theories from Jean Piaget, Lev Semyonovich, Vygotsky, and other theories related to constructivism learning theory andlearning design (Saputro & Pakpahan, 2021). The constructivist perspective states that the role of the educator in problem-based learning is as a person who provides *feedback* and reflects on the learners' learning process and group dynamics (Maryati & Monica, 2021).

Specifically, problem-based learning is a learning approach that confronts students with pragmatic, ill-structured, or open-ended problems through a stimulus in learning. In addition, Problem-Based Learning is a learning strategy that simultaneously develops problem-solving strategies, knowledge disciplines, and skills to place students in problem-solving activities by confronting problem structures in theform of real-world problems. Problem-based learning can be considered one of the learning approaches that challenge students or students as learners to learn and worktogether in groups to find adjustments to real problems in their lives (Syah et al., 2019).

According to Amidi and Zahid (2017), there are some characteristics of Problem-Based Learning. Among them are as follows: (1) submission of questions or problems, in Problem-Based Learning activities, teaching is organized around questions or problems that are both socially important as well as personally meaningful; (2) focusing on interdisciplinary linkages, meaning that the problem being investigated can be viewed from many things; (3) authentic investigation, in which learners gather relevant information to conduct experiments, seek explanations and solutions with guidance from educators; (4) produce products or explanations that represent the form of problem-solving found; and (5) thereis cooperation in investigating a problem, identifying sources of information, discussing possible problem solving and presenting the results obtained.

The description of problem-based learning above shows that Problem-based learning has an important idea: it provides a learning environment with problems as its basis. Learning can be achieved if educational activities are centered on authentic, contextual, and relevant tasks or problems, such that students need to interpret the problem, gather the necessary information, evaluate alternative solutions, and present the solution they believe in.

Some Problem-Based Learning formats that can be applied in learning are as follows: (1) problems are given at the beginning of learning before preparation or during learning; (2) problem situations are presented to students in the same way but should be presented naturally; (3) students work with problems that match their level of knowledge, making it possible for them to reason and apply knowledge to answer challenges and to be assessed; (4) learning areas expressed as problems are required, which are explored and used as guides in individualized study; (5) skills and knowledge gained in individualized study are applied in problems to evaluate the effectiveness of learning and to reinforce learning; and (6) learning gained through working with problems and independent learning is summarized and integrated in the knowledge and skills possessed by the students.

From the whole description of the implementation of Problem-Based Learning, it indicates that the existence and role of the teacher as a facilitator is crucial (Andeswari et al., 2022; Astuti, 2021; Istiqomah & Indarini, 2021; Krisnayanti & Wiarta, 2022; Sukmawati, 2020). Although students learn more independently, the teacher has a role that cannot be ignored. The role of the teacher as a facilitator must refer to the implementation of approaches that remove learning barriers and return the learning process to its 'easy' state. In addition, teachers must work hard in monitoring the activities of their students, activating the learning process, and stimulating them with questions so that the stages of physical and mental activity (thinking) of students in learning are integrated with GeoGebra software as a tool to in visualize students' problems more effectively and efficiently, to foster optimal students' curiosity (Feriyanto, 2020; Karuniakhalida et al., 2019; Lestari & Sundi, 2021; Nufus & Anggraini, 2022).

CONCLUSION

This study was conducted on 61 students, 30 of whom were experimental class students and 31 were control classes. It was found that the pre-test data was not normally distributed. In contrast, the post-test and N-Gain data were normally distributed, with the difference in students' initial ability in the experimental and control classes. It was also known that the final ability of students in learning using Problem-Based Learning (PBL) assisted by GeoGebra was better than the class that used conventional learning or control learning; this was evidenced by the significance value, which was less than 0.05 or in other words the hypothesis H0 was rejected. In addition, this study found an improvement in students' creative thinking skills supported by learning using GeoGebra software, which had a very significant effect. This indicates that using Problem-based Learning (PBL) assisted by GeoGebra is better than conventional learning in terms of improving students' creative thinking skills.

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