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Research Article

INTERACTION OF PROBLEM-BASED LEARNING AND LEVEL OF CREATIVITY ON MATHEMATICS LEARNING OUTCOMES

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Abstract

Mathematics is a pure science subject that is assumed by some students to be a difficult subject. This is influenced by internal and external factors of learners. One of the internal factors is the ability to think creatively and one of the external factors is problem-based learning model. This study aims to see the interactions that occur between the model problem-based learning and the ability to think creatively on mathematics learning outcomes. Quasi-experimental was chosen to be the type of research used in the study with 129 students as subjects. Data were collected from the results of student tests and then tested the hypothesis using a two-way ANOVA test. The results showed that there was an interaction between problem-based learning model and the ability to think creatively on mathematics learning outcomes.

Keywords: Problem based learning, Creative thinking skills, Mathematics learning outcomes.

INTRODUCTION

Mathematics is a pure science subject that is assumed by some students to be a difficult subject. Reys said that mathematics is a study of patterns and relationships, a path or mindset, an art, a language and a tool (Isrok'atun *et al.,* 2020). Mathematics can connect all fields of science by describing it in numbers. Math is difficult to understand because it is a number. Learning mathematics is connected in a fun, everyday life and an increase in the learner's imagination provides a more effective learning environment (Cenberci, 2018). Learning outcomes are obtained from the learning process that has been done before. These results are influenced by two factors, namely internal that comes from within a person such as the ability and condition of the learner, as well as external factors that come from outside such as strategies and learning models used in conveying the material. Learning outcomes will achieve the learning objectives if the strategies and learning models used are in accordance with the characteristics of the learners, the abilities of the learners and the learning materials so that the learning atmosphere becomes comfortable and easier to understand. This implies that the use of learning strategies and models can also affect learning outcomes. Meanwhile, one of the internal factors is the ability to think creatively. If a person has the ability to think creatively, he can solve various problems with a variety of problem-solving solutions. Mathematics has three levels, namely the implementation of mathematical rules and procedures in the real world as the first level, then algorithmic activities that aim to solve problems as the second level, and the third level contains creative thinking skills that aim to integrate the implementation of mathematics in solving problems (Siswono, 2010). This shows that the ability to think creatively is one of the abilities needed to solve mathematical problems. Problems faced in mathematics will be easier to solve with a variety of solutions. The learning model also affects learning mathematics. If the learning model used is not in accordance with the characteristics of the learner, the learning atmosphere and the characteristics of the material, the learning objectives that will be achieved will not be realized. One of the achievement of learning objectives can be seen in the learning outcomes obtained by students. Problem-based learning problem-based learning is a learning model that is often used to teach students to find solutions in various ways and thoughts of a proposed problem. The problem-based learning has a relationship with the ability to think creatively in learning mathematics. This is proven in several scientific journals. Problem based learning can affect students' creative thinking skills in mathematics learning applies to students with high levels of ability, while low ability level learners only touch fluent and flexible aspects provided that there is assistance with certain approaches (Munahefi *et al.,* 2017). Problem based learning can affect the ability to think creatively in mathematics provided that students have a high level of ability so that the implementation of problem-based learning can improve all aspects of the ability to think creatively in mathematics. There is also amodel problem-based learning that can develop mathematical creative thinking skills using an open approach but the improvement does not increase drastically but step by step through the analysis of a problem (Maskur *et al.,* 2020). This study shows that there is an interaction between the model problem-based learning and the ability to think creatively in mathematics. This makes the basis for researching the interaction between model problem-based learning with the ability to think creatively on mathematics learning outcomes. Problem-based learning is one of the most innovative learning models through providing authentic problems to learners in the learning process in order to build new knowledge obtained from solving problems independently (Birgili, 2015). The operational steps of problem-based learning are basic concepts, problem definition, independent learning, knowledge exchange, and assessment. The steps for problem-based learning include observing, gathering information and experimenting, associating or processing information, communicating and asking questions.
The effects that are used as indicators of the assessment of learning methods in different conditions are the results of learning. The real learning outcomes are using a method under certain conditions, while the desired learning outcomes are the

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selection of methods to be used in accordance with the objectives to be achieved and have an effect on the learning plan decisions, both learning outcomes are manifestations of learning outcomes (Degeng, 1997; Reigeluth (1983); Uno *et al.* (2010). Furthermore, Degeng (1997); Reigeluth (1983), Uno *et al.* (2010) stated that in general learning outcomes can be classified into three, namely: (1) effectiveness learning, (2) learning efficiency, (3) learning attractiveness. The test instrument used to measure the cognitive aspects of learning outcomes is the description test. The test instrument is directed to measure the students' ability to remember (C1), understand (C2), apply (C3), and analyze (C4). Creative thinking can be defined as a set of cognitive activities that are used independently based on an object that is specific, problems or conditions or a type of effort in a part of the activity or problem based on the capacity of each individual (Birgili, 2015). This proves that creative thinking has a relationship in solving problems with the abilities possessed by these individuals. Several tests were conducted to measure creativity, namely Guilford's divergent thinking ability test, Torrance's creative thinking ability test, creative-productive thinking test, creative-thinking test with sounds and words, and creative thinking test with a knowledge-Torrance inventory. Measuring creativity, there are several aspects that are used as measurement indicators, namely fluency, flexibility, authenticity, decomposition, and formulation.

METHODS

This study used a quasi-experimental research type to control all variables that are assumed to have an effect through the treatment or the impact on the treatment given. The subjects in this study were students of class XI in the science program from SMAN 3 Bojonegoro and SMAN 4 Bojonegoro with the 2019/2020 school year. The description of the research subjects were 65 students from SMAN 3 Bojonegoro as the experimental group and 64 students from SMAN 4 Bojonegoro as the control group. The experimental group applied problem-based learning model and control group applied guided discovery learning model. The variables used in this study were the model problem-based variable independent, the ability to think creatively as the moderator variable and mathematics learning outcomes as the dependent variable. Data collected from these variables using data collection types of tests and observations data Post-test after giving the treatment was tested by t test. Then to see the interaction of the model problem-based learning with the ability to think creatively on mathematics learning outcomes, it is carried out using the two-way ANOVA test to test the hypothesis. The hypothesis tested is that there is a significant interaction between the learning model and the ability to think creatively on mathematics learning outcomes.

RESULTS

The test was conducted to test the mathematics learning outcomes of the treatment by applying a model problem-based learning to mathematics learning. The data description math achievement test material obtained through the calculation of descriptive statistics in the experimental group and the control group, shown in Table 1. The data is then analyze by testing using the two-way ANOVA test. This test was assisted by the SPSS version 16 program using a significance level of 0.05. This data is shown in Table 2. The results of data computation in table 2 test the interaction hypothesis between models problem-based learning and the ability to think creatively on mathematics learning outcomes, namely F_{count}= 4.651 with a significant level α = 0.033 being at below the significance level of 0.05 (0.033 <0.05), thus $H_{0\ is}$ rejected. So the meaning is that there is an interaction between the model problem-based learning and the ability to think creatively on mathematics learning outcomes. The results of hypothesis testing and descriptive statistics revealed that, (1)the application of the model problem based learning with a high level of creativity was categorized as high and the application of the model problem based learning with a low level of creativity was categorized as sufficient; (2) there were differences in learning outcomes from groups of students with high levels of creativity and low levels of creativity who applied a model problem-based learning; and (3) the application of the model problem based learning can lead to creative thinking in learners. Problem based learning can affect students' creative thinking skills in mathematics learning applies to students with high levels of ability, while low ability level learners only touch fluent and flexible aspects provided that there is assistance with certain approaches (Munahefi *et al.,* 2017).

Table 1. Data on mathematics learning outcomes

Instructional Model	Level of Creativity	Max Score	Min Score	Mean	SD	N
Problem based learning	High	100	55	80,88	10,764	34
	Low	100	45	70,16	12,746	31
	Total	100	45	75,77	12,846	65
Guided discovery learning	High	100	65	81,36	9,123	33
	Low	95	60	78,87	10,465	31
	Total	100	60	80,16	9,798	64

Table 2.Anova test results

Dependent Variable: Learning outcomes					
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Corrected Model	2583.777[a]	3	861.259	7.350	.000
Intercept	779951.916	1	779951.916	6656.314	.000
Creativity	1405.469	1	1405.469	11.995	.001
Model	679.974	1	679.974	5.803	.017
Creativity * model	545.005	1	545.005	4.651	.033
Error	14646.843	125	117.175		
Total	800975.000	129			
Corrected Total	17230.620	128			

a. R Squared = .150 (Adjusted R Squared = .130)

The aspect of fluency in this case is meant by providing lots of ideas, questions, solving problems and questions, while the flexible aspect in this case is meant by generalizing ideas, solutions and questions obtained from changes or changes in solutions according to problems from various views or other alternatives. This supports the results of applying the model problem-based learning with a high level of creativity in a high category. It means that the application of the model is problem-based learning effective for students with a high level of creativity but less effective in its application for students with a low level of creativity. Most learners do not understand the importance of learning management for the development of creative thinking and do not understand its application in developing creative thinking skills (Sriwongchai *et al.,* 2015). Problem based learning is also said to be effective in developing creative thinking in mathematics if learners understand the learning model and have a goal to develop creative thinking skills. The difference in mathematics learning outcomes in students with high levels of creativity and low creativity through the application of a problem-based learning model. This is supported by the statement that the ability to think creatively in mathematics in low-ability students by applying a model problem-based learning will find it difficult to solve problems appropriately (Munahefi *et al.,* 2017). Abstract problems make students with a low level of ability difficult to solve it is caused by the characteristics of the learners towards the ownership of the initial abilities of these learners.

The model is the problem-based learning development of constructivism theory which teaches students to build new knowledge from their knowledge. Finding solutions to problems makes memory work heavy. High working memory cannot accumulate knowledge in long-term memory because memory works to find solutions to existing problems, not learning (Birgili, 2015). This causes not all students to develop creative thinking skills through problem-based learning. The model problem-based learning can lead to creative thinking skills. This is supported by several statements that the model problem-based learning can lead to creative thinking skills with the help of software certain (Tan *et al.,* 2002) and compact discs learning (Nugroho *et al.,* 2013). In Problem Based Learning model, the learning steps focus on presenting an abstract problem to the learner, and it is continued with discussion activities and looking for references from learning sources as a comparison of data (problem studies) with theory. Problem-based learning model works to develop creativity and is consistent with pure mathematics because it makes students closer to the entire process of creativity as they work to find various solutions to a problem they face, this is a process of creativity (Mrayyan, 2016). This explanation shows that the model problem-based learning has an effect on developing creative thinking skills.

Conclusion

The results of hypothesis testing and descriptive statistics prove that there is an interaction between problem-based learning model and the level of creativity on mathematics learning outcomes. The application of the model is problem-based learning effective for high-ability learners so that it can lead to the ability to think creatively in mathematics.

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