



Problem-based learning textbook: Its effect on improving creative thinking skills

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Abstract

Mathematics textbooks that provide more descriptions of material and routine problems used so far cannot facilitate students in active learning activities. The lack of active students in learning activities causes creative thinking skills not to develop optimally. This paper aims to describe how problem-based learning textbooks can facilitate students in solving problems with different or varied solutions and even something new to foster creative thinking skills. This problem-based textbook has been developed and is one of the research products of IAIN Metro lecturers in 2021. This research is an experimental study consisting of experimental and control groups. Data collection techniques using tests and observations. The test data were analyzed using the mean difference test using the Mann-Whitney formula, while the observation data were analyzed using a descriptive qualitative approach. The findings of this study are constructive learning activities and open problems contained in problem-based learning textbooks significantly improve creative thinking skills. It is shown that the increase in creative thinking skills of students who study using problem-based learning textbooks is substantially higher than students who study using other textbooks. Thus, problem-based learning textbooks contribute to improving students' creative thinking skills.

INTRODUCTION

Mathematics textbooks that are mostly rote and present quick formulas do not support the development of higher-order thinking skills (Agustyarini & Jailani, 2015), such as creative thinking skills. Learning mathematics is not enough just to reading, memorizing, and counting; students need to be trained to do reasoning, analysis, and creative thinking activities in solving mathematical problems (Amidi & Zahid, 2017; Hidayat & Ihsan, 2020; Marlioni, 2015). Textbooks that present open-ended problems and constructive learning activities make students actively involved in learning activities (Dalim & Yusof, 2013; Törnroos, 2005) and become a powerful tool for developing mathematical skills (Weinberg & Wiesner, 2011). The textbooks are needed to increase student competence which is still low. As the data shows that students' mathematical creative thinking skills are still low (Faelasofi, 2017; Meika & Sujana, 2017), especially students who have low abilities (Suripah & Sthephani, 2017), even have difficulty using principles and concepts in solving mathematical problems (Nurangraeni et al., 2020). Under these conditions, using appropriate mathematics textbooks according to student needs can encourage student involvement in learning activities that allow the development of mathematical abilities.

Several existing studies on improving creative thinking skills in solving mathematical problems are mostly done using learning models. Most studies show problem-based learning models are used to improve creative thinking skills (Amidi & Zahid, 2017; Cahyaningsih &

Asikin, 2015; Hidayat & Ihsan, 2020; Kiptiyah et al., 2016; Malau, 2021; Ramadhani et al., 2020. In addition, creative thinking skills are improved using the discovery & scaffolding learning model (Jatisunda et al., 2020). From this trend, only the components of the learning model are the emphasis on improving creative thinking skills, ignoring textbooks as one of the most important components in achieving competence. Meika & Sujana (2017) research results also suggest research on textbooks on creative thinking and problem-solving abilities. Vojř & Rusek (2019) stated that the importance of textbooks in learning is undeniable, and the results of their research stated that from 2000-2018 researchers in Europe and the United States focused more on textbook research than researchers in other countries. Based on these considerations, problem-based learning textbooks have been developed and declared suitable for use by experts for use in learning.

This paper aims to complement the shortcomings of existing studies that only emphasize the use of learning models by analyzing other components, namely using textbooks to improve students' creative thinking skills. In this regard, three questions can be formulated: (1) What are the characteristics of mathematics textbooks used in learning mathematics? (2) How is the involvement of students when using mathematics textbooks? and (3) How can mathematics textbooks improve creative thinking skills? These questions illustrate how important textbooks are in encouraging students to actively participate in learning activities to help improve creative thinking skills.

This paper explains that developing creative thinking skills in solving mathematical problems requires opportunity and practice during learning. Opportunities for students to solve mathematical problems that are open so that they can complete more than one correct answer, solve them in different ways, and even with new solutions. Learning activities also increase through opportunities and exercises during the learning process, which provides opportunities to improve creative thinking skills. Therefore, the learning process, which has emphasized using only learning models, needs to be expanded to use textbooks that can encourage students to participate in learning activities during class and independent learning actively. Thus, students can solve mathematical problems correctly and creatively, including higher-order thinking skills.

METHODS

Design

This study is an experimental study involving two groups given different treatments. The experimental group was given learning treatment using a problem-based learning textbook entitled "Geometry and Measurement: Creative in Solving Mathematical Problems," called book A. The control group used a textbook called "Mathematics" called book B. This research uses a "Control Group Pretest-Posttest Design." The research design is as follows in Figure 1.

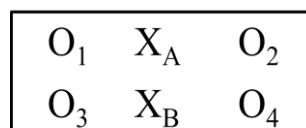


Figure 1. Control Group Pretest-Posttest Design

Information:

- O_1 : Pretest score (before being treated) in the experimental group
 X_A : The treatment is the implementation of learning by using textbooks based on problem-based learning (textbook A)
 X_B : The treatment is the implementation of learning by using textbooks LAPIS PGMI (textbook B)
 O_2 : Posttest scores (after being treated) in the experimental group
 O_3 : Pretest score (before learning) control group
 O_4 : Posttest score (after learning by using textbook B)

The implementation procedure can be seen in Figure 2.

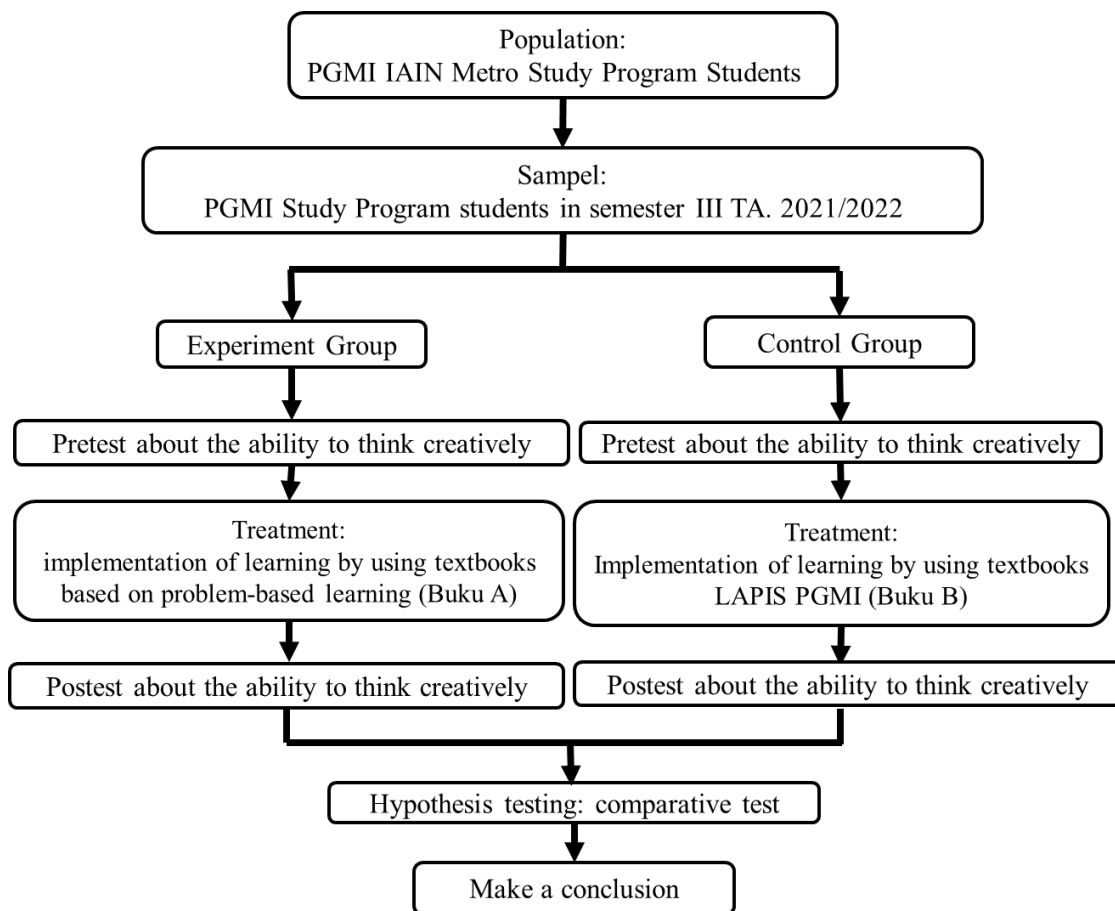


Figure 2. Research Procedure

Participant

The participants in this study were 53 students consisting of 32 experimental and 21 control class students. The determination of these students is because 1) the results of the initial identification show that they have poor creative thinking skills in geometry material; 2) third-semester students are taking mathematics courses, one of which is geometry. The object of this research is the ability to think creatively in solving mathematical problems, which is improved through problem-based textbooks.

Instrument

The instrument used is tests and observations. The test is used to get data on creative thinking skills. The tests that are arranged are open questions related to geometry material. The test has been validated by experts and declared feasible so that it can be used to measure creative thinking skills. The test was given before and after treatment to determine the increase in creative thinking skills and the differences in the improvement in thinking skills in the two groups. Observation is used to determine the learning process using problem-based learning textbooks.

Data Analysis

The data analysis technique is the average difference test of increasing creative thinking skills in the experimental and control group students. The formula used is Mann-Whitney (U). The test criteria are H_0 is accepted if $Asymp.Sig. \geq 0.05$. The level of significance in this test is 0,05. Furthermore, the analysis of the data from the observations was carried out descriptively.

RESULTS AND DISCUSSION***Result***

This section describes the learning process using problem-based textbooks, which are divided into three parts, are:

1. Profile of Textbooks Used in Learning Mathematics

The textbooks used in this study were Textbook A and Textbook B. The profiles of the two textbooks were described into three components.

a. Learning Objectives

Learning objectives contained in the textbooks can be identified by reviewing each competency from the two books and then making conclusions. The results of the study of each competency from the two textbooks are described in Table 1.

Table 1. Learning Objectives in Mathematics Textbooks

Textbook	Learning Objectives
Textbook A	- Through discovery activities, students can explain the concepts of triangles, congruence, flat shapes, and geometric shapes. - Students can solve problems related to geometry creatively
Textbook B	- Students understand the concept of triangle, congruence, congruence, flat shapes, and geometric shapes. - Students can use the concept of geometry to solve problems.

Table 1 explains that, in general, the learning objectives in the two textbooks include competency in mastering geometric concepts and problem-solving. There are similarities between the two textbooks, namely mastery of the competencies of knowing, understanding, and applying as low-level competencies. In addition, the two books have differences, namely problem-solving. Book A wants students to be able to solve problems creatively. Creativity means that students can solve questions correctly and with correct, varied, and new answers. Creative thinking is the highest level in the cognitive domain. At the same time, book B includes problem-solving as an application capability that only uses geometric concepts in solving problems. Application is a level 3 cognitive competency that includes low-level thinking skills. Thus, book A includes mastery of higher competencies than book B.

b. Geometry Material

The geometry material studied in textbooks can be identified by examining each sub-material from the two books and making conclusions. The results of the study of each geometry material from the two textbooks are described in the following table.

Table 2. Geometry Material in Textbooks

No	The material in Book A	The material in Book B
1.	Triangles, similarity, and congruence	Triangles, similarity, and congruence
2.	The plane consists of 1) square, 2) rectangle, 3) trapezoid, 4) parallelogram, 5) rhombus, 6) kite, and 7) circle	The plane consists of 1) square, 2) rectangle, 3) trapezoid, 4) parallelogram, 5) rhombus, 6) kite, and 7) circle
3.	Geometric solid consists of 1) cube, 2) cuboid, 3) prism, 4) pyramid, 5) cylinder, 6) cone, and 7) sphere.	Geometric solid consists of 1) cube, 2) cuboid, 3) prism, 4) pyramid, 5) cylinder, 6) cone, and 7) sphere.

Table 2 describes that the geometry material studied in both textbooks is the same, which includes 1) triangles, similarity, and congruence, 2) plane, dan 3) geometric solids. Thus, there is no difference in the material studied in book A dan book B.

c. Learning Activities in Textbooks

The learning activities in the textbooks can be identified by examining each learning activity contained in the two textbooks. The results of the study of each learning activity in the two textbooks are presented in the following table:

Table 3. Learning Activities in Textbooks

Learning Activities	Book A	Book B
Solving problems at the beginning of learning	8 activities	15 activities
Construction of understanding (answering questions to make conclusions)	7 activities	-
Find the formula	<ul style="list-style-type: none"> - 8 activities to find the formula for the circumference of a flat shape - 8 activities to find the formula for the area of a flat shape - 7 activities to find the formula for the surface area of a geometric shape - 7 activities to find the volume formula of a geometric shape 	-
Read material	<ul style="list-style-type: none"> - Brief material description - The material is presented after solving problems at the beginning of the meeting, building activities, and finding concepts to strengthen student understanding. 	<ul style="list-style-type: none"> - Long material description - Presentation of material after the activity of solving problems at the beginning of the meeting
Study sample questions	48 questions, along with several alternative answers/solutions	32 questions and answers/solutions
Practice doing routine problems	15 routine problems	18 routine problems
Practice doing non-routine problems	40 non-routine problems dan 15 open-ended problems	15 non-routine problems

Formative test	30 non-routine problems dan open-ended	30 routine problems dan non-routine problems, 20 multiple-choice questions
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Table 3 describes more learning activities provided in textbook A than in book B, namely activities to build understanding, find formulas, and open-ended problems. However, book B provides more material descriptions than book A.

2. Student participation during the application of mathematics teaching materials

Student participation during the use of mathematics textbooks is described in three activities.

a. Knowledge construction

One activity that can encourage students to think more actively in knowledge construction. Knowledge construction is a thinking activity in associating new information with existing knowledge and then changing the information obtained to form a comprehensive understanding of knowledge. This activity aims to allow students to connect new material with their knowledge and construct the concept of geometric shapes themselves, thereby strengthening their existing understanding or even forming new knowledge. The construction activities provided in problem-based textbooks include making their understanding of trapezoidal, parallelogram, and other shapes. Based on the observation, results showed that as much as 16% were included in the high category, 63% in the medium category, and 22% in the low category. A description of the student's ability to construct knowledge is shown in Figure 3.

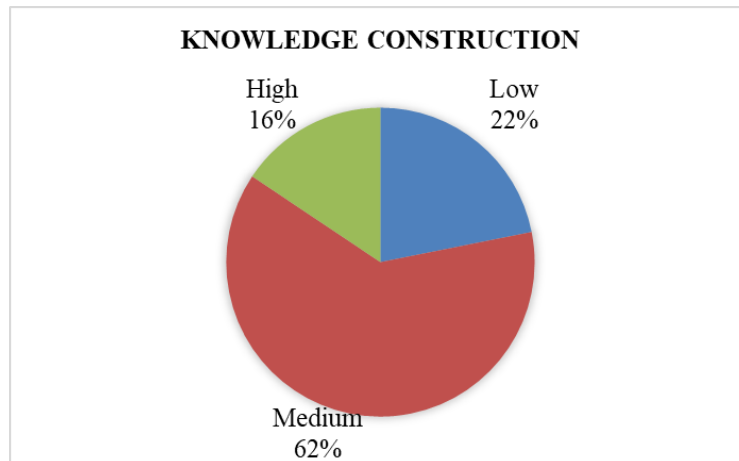


Figure 3. Knowledge Construction Ability

Figure 1 describes students' abilities in constructing knowledge: high, medium, and low categories. In the figure, it can be explained that more than 50% of students fall into the medium and high categories in constructing knowledge. The data shows that problem-based textbooks used in learning can help students be actively involved in solving problems, answering several questions, and making conclusions that involve thinking activities that link new information with their understanding, resulting in knowledge construction and forming more meaningful knowledge.

b. Finding Concepts/Formulas

Discovery is an activity that can help students to be actively involved in thinking to find a concept/procedure for themselves. This activity aims to facilitate students in discovering a formula in geometry through stimulating questions to form knowledge and discover a concept. Some examples of discovery activities found in problem-based textbooks are finding the formula for the circumference and area of a plane figure, finding the formula for the surface area and volume of a geometric shape, and so on. The observations showed that as many as 25% were in the high category, 56% were in the medium category, and 19% were in the low category. A description of the student's ability to find concepts/formulas is shown in Figure 4.

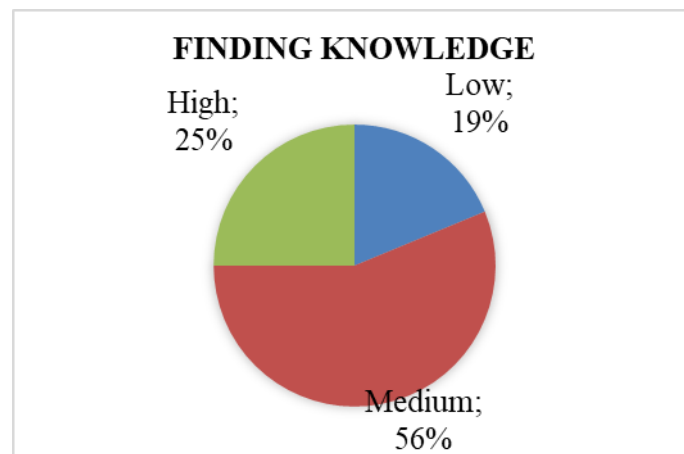


Figure 4. Ability to Discover Knowledge

Figure 2 describes that more than 50% of students can find a concept in geometry material using problem-based textbooks, which are medium and high. Thus, the problem-based textbooks used during learning can make students participate more actively in finding a concept/formula in geometry material.

c. Creative Thinking in Solving Problems

Solving problems is part of a high-level thinking process that involves many complex thinking activities. Solving a problem is an activity that encourages students to think creatively in solving math problems. The purpose of this activity is to provide opportunities for students to participate actively in solving problems according to their abilities by making 1) correct and varied solutions (fluency), 2) various possible solutions (flexibility), and 3) solving unusual or new (novelty). The observations show that the average student's ability to solve problems, fluency, flexibility, and novelty, is in the moderate category. The results of these observations are presented in Figure 5.

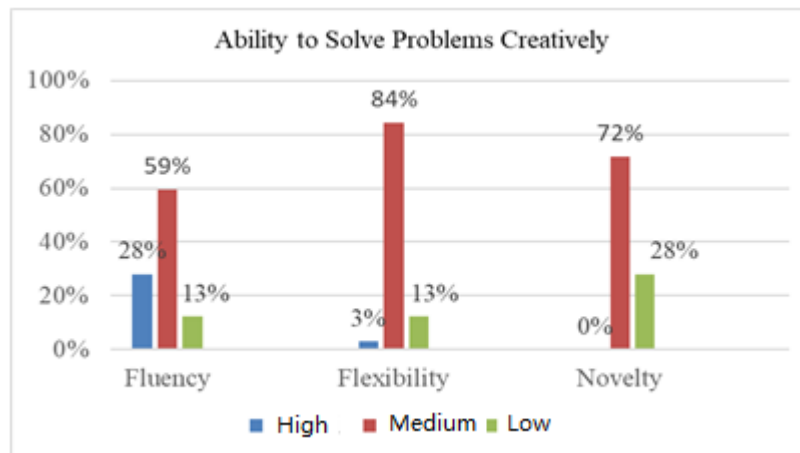


Figure 5. Ability to Solve Problems Creatively

Figure 3 shows that in solving math problems, 87% of students show fluency in the high and medium categories, 87% show flexibility in the high and medium categories, and 72% show novelty in the medium and no high categories. The description of creative thinking abilities explains that students are getting used to solving problems correctly and diversely, carrying out solutions in various ways, and making unusual or even new solutions. Thus, the problem-based textbook used in this study has shown its contribution to providing opportunities for students to carry out open-ended problem-solving activities that provide opportunities to grow and improve creative thinking skills.

3. Improvement of Creative Thinking Ability

Increasing creative thinking skills can be identified by looking for differences in students' creative thinking abilities before and after learning, namely calculating the difference in the average pretest and posttest scores. The results of calculating the pretest and posttest scores of experimental and control class students are presented in the following table.

Table 4. Average Pretest and Posttest Scores of Students' Creative Thinking Ability

Group	Average Pretest Score	Average Posttest Score
Experimental	37,56	67,34
Control	37,62	61,14

Table 4 describes that students in both the experimental and control classes have higher creative thinking skills after learning with the mathematics teaching materials than before participating in learning. Furthermore, to find out whether the differences in creative thinking abilities after learning in the two groups were significantly higher than before learning, a test was conducted to test the difference in pretest and posttest averages. The test for the difference in the mean of the two samples used was the Wilcoxon test because the pretest and posttest average scores for both the experimental and control classes were not normally distributed. The results of the pretest and posttest mean difference test are presented in the following table:

Table 5. Different Test Results of Average Pretest and Posttest Ability to Think Creatively

Group	Wilcoxon test results Post Test – Pretest		Conclusion
	Z	Asymp. Sig.(2-tailed)	
Experimental	-4,789 ^a	0,000	There is a difference
Control	-3,807 ^a	0,000	There is a difference

Table 5 shows the significant Asymp. value of the two groups of 0,000. Because of the Asymp.significant value is 0,000, which is lower than 0,05, H_0 is rejected. It means there is a significant difference between students' creative thinking abilities before and after learning using mathematics teaching materials in the experimental and control classes. Students' ability to think creatively after participating in different learning is significantly higher than before learning. Thus, the two textbooks can improve students' ability to think creatively.

Furthermore, to find out which textbooks are more capable of increasing creative thinking skills, it is necessary to test the differences in the increase in creative thinking abilities of students in the experimental class and control classes. Increasing students' creative thinking skills in solving math problems can be seen by calculating the normal gain. The results of calculating the normal gain for creative thinking abilities of students in the experimental class and control class are presented in the following table.

Table 6. Average Normal Gain Creative Thinking Ability

Ability	Experimental Group		Control Group	
	Average	Category	Average	Category
Creative Thinking	0,52	Medium	0,38	Medium

Table 6 describes that experimental class students experienced a higher increase in creative thinking skills after participating in learning using mathematics teaching materials than control group students.

Furthermore, a difference test was performed on the average normal gain score to determine whether the increase in the ability to think creatively in the experimental class students was significantly higher than in the control class. The Mann-Whitney (U) test for the mean difference between the two samples was used because the normal gain scores for the creative thinking abilities of the experimental and control classes were not normally distributed. The results of the mean difference test for the intended Normal Gain are presented in the following table.

Table 7. N-Gain Mean Different Test Results for Creative Thinking Ability

<i>Test Statistics^a</i>	
	Nilai
Mann-Whitney U	210.000
Wilcoxon W	441.000
Z	-2.292
Asymp. Sig. (2-tailed)	0.022

a. Grouping Variable: Kelas

Table 7 shows a significant Asymp. value of 0,022. Because the significant Asymp value is 0,022, which is lower than 0,05, H_0 is rejected. This means that there is a significant difference in improvement between the creative thinking abilities of students in the experimental and control classes. The increased creative thinking skills in students who studied with problem-based textbooks were significantly higher. Thus, problem-based textbooks increase students' creative thinking skills more effectively.

Discussion

Based on the research results above, it has been shown that problem-based mathematics textbooks are proven to be more effective in increasing creative thinking skills. Improving the ability to think creatively is inseparable from the characteristics of the textbooks used during learning. Using textbooks that provide constructive learning activities and various types of mathematical problems, whether contextual, non-routine, or open-ended, is more effective in increasing creative thinking skills.

The success of problem-based textbooks in increasing creative thinking skills has emphasized that not all textbooks can facilitate the maximum improvement of higher-order thinking skills. Still, textbooks can engage students in constructive learning activities and solve problems creatively. Constructive learning activities such as building understanding and finding concepts/procedures provided in textbooks provide broad opportunities for students to build their concepts/procedures being studied. Making their notions of triangles, rectangles, and others can strengthen students' understanding. Ramaraj & Nagammal (2016) explained that strengthening understanding could be done through intensive involvement in discovering a concept. Thus, the accuracy of selecting mathematics textbooks used in learning activities is very important.

The accuracy of determining the textbook used affects the achievement of the expected competencies. The accuracy of a textbook is shown by how the book can facilitate students to achieve better competence. Achieving higher competence can occur if students play an active role in completing assignments (Haddar, 2017; Siahaan et al., 2021; Törnroos, 2005), allows students to study independently according to their own pace (Dalim & Yusof, 2013). The urgency of open-ended activities or assignments is to provide space for students to learn various strategies, deepen their knowledge of mathematics, and develop creative thinking (Savic, 2019). Thus, good and appropriate criteria become necessary in compiling or selecting books as a learning resource and a means to achieve learning goals.

In addition to constructive learning activities, various problems, both routine, non-routine, or open-ended problems, also have a role in strengthening understanding and increasing creative thinking skills. Strengthening understanding occurs when students solve various types of math problems. Open problems have allowed students to solve problems with correct, varied, and even new solutions. Widyastuti (2021) explained that in solving mathematical problems, prior knowledge of mathematics is also needed to assist and facilitate students. Some research results in state that the determination of open problems supports making alternative solutions or solutions (Felin & Zenger, 2014) and generates innovative solutions (Ramaraj & Nagammal, 2016). Open-ended problems are the first step to connecting students' mathematical literacy with real-world situations (Savic, 2019). Thus, textbooks that provide various problems, especially open-ended problems, are appropriate for improving creative thinking skills.

Implication

The implications of the findings of this study for the mathematics learning process include 1) designing mathematics learning that can make students actively participate in learning activities, 2) learning activities that support students actively participating in learning and using open-ended questions can develop critical and creative thinking skills (Monrat et al., 2022), 3)

choose or determine the right textbook and according to the needs of students in achieving competency.

Limitations and Suggestions for Further Research

This research has limitations; namely, it was only conducted on 53 students of the Madrasah Ibtidaiyah Teacher Education study program at IAIN Metro, totaling 53 people, or it had yet to be carried out on a wider scale. In addition, the material provided in textbooks is only related to geometry. Only three indicators of creative thinking ability were studied: fluency, flexibility, and novelty. Based on these limitations, further relevant research can be carried out by involving more students in various tertiary education institutions, broader mathematics material, and other higher-order thinking skills needed.

CONCLUSIONS

Problem-based textbooks are appropriate for improving creative thinking skills in solving math problems. The textbook's accuracy is shown from this study's results that problem-based textbooks are more effective in increasing creative thinking skills than other mathematics textbooks. Constructive learning activities and open problems provided in textbooks can make students actively involved in building knowledge and provide opportunities to solve problems creatively.

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