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The Effect Of Stem-Based Project-Based Learning In Improving High School Students' Visual Mathematical Ability

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ABSTRACT

Penelitian ini didasarkan pada permasalahan masih rendahnya kemampuan visual thinking matematis dalam pembelajaran matematika. Untuk mengatasi hal tersebut, dilakukan penelitian dengan menggunakan model Project-Based Learning berbasis STEM (PjBL-STEM). Penelitian ini mengkaji masalah peningkatan kemampuan visual matematis antara siswa yang mendapat pembelajaran matematika dengan model Project-Based Learning berbasis STEM (PjBL-STEM). Penelitian ini merupakan penelitian kuasi eksperimen, desain yang digunakan adalah Nonequivalent Control Group Design dengan menggunakan teknik Purposive Sampling. Populasi dalam penelitian ini adalah siswa SMA di Kabupaten Bandung Tahun Pelajaran 2021/2022, dengan sampel penelitiannya adalah Siswa SMA kelas X. Instrumen yang digunakan dalam penelitian berupa tes kemampuan visual matematis. Analisis data dilakukan secara kuantitatif dilakukan dengan menggunakan Independent Sample t-test. Hasil penelitian menunjukkan bahwa, (1) Secara keseluruhan penerapan model pembelajaran PjBL-STEM dapat meningkatkan kemampuan kemampuan visual thinking matematis siswa, (2) Peningkatan kemampuan visual thinking matematis siswa yang pembelajarannya menggunakan model pembelajaran PjBL-STEM secara signifikan lebih baik dibandingkan dengan siswa yang pembelajarannya menggunakan model pembelajaran konvensional.

ABSTRAK

This research is based on the problem of the low mathematical visual thinking ability in learning mathematics. To overcome this, research was carried out using a STEM-based Project-Based Learning (PjBL-STEM) model. This study examines the problem of improving visual mathematical abilities among students who receive mathematics learning with the STEM-based Project-Based Learning (PjBL-STEM) model. This research is quasi-experimental, the design used is the Nonequivalent Control Group Design using the Purposive Sampling technique. The population in this study were high school students in Bandung Regency in the academic year 2021/2022, with the research sample being high school students in class X. The instrument used in the study was a visual mathematical ability test. Data analysis was carried out quantitatively by using the Independent Sample t-test. The results showed that (1) Overall the application of the PjBL-STEM learning model could improve students' mathematical visual thinking abilities, (2) Improved mathematical visual thinking skills of students whose learning using the PjBL-STEM learning model was significantly better than students who learned using conventional learning models.

INTRODUCTION

Mathematics was a basic science that is widely applied in various aspects of life. According to Permendikbud No. 58 of 2014, mathematics plays an important role in various fields so that it can be beneficial to human life. One of the goals that cannot be separated from learning mathematics and were an important issue in developing science, technology, and art is solving problems and developing mathematical visual abilities (Darmadi & Handoyo, 2016; Yuwono et al., 2018).

In Accord with to (Hadi & Radiyatul, 2014), problem-solving is the process of finding a combination of several rules or methods that can be applied to solve a problem. The ability to solve problems refers to the efforts and abilities that exist in students to solve a problem so that they can achieve the expected goals and results (Suryani et al., 2020). Students must have mathematical problem-solving skills so that students can be alert to deal with various types of problems that arise in life, especially in the field of mathematics (Zulfitri, 2019).

The ability to solve math problems with pictures is an ability that was very necessary for the process of learning mathematics because it was the first step to solving a problem. When students face a problem, they need to visualize the problem and then represent it mathematically. solutions (Aini & Hasanah, 2019; Darmadi & Handoyo, 2016). This mathematical visualization will determine the next stage of completion. However, based on the results of previous research, there is a tension between the goals and their temptations. Previous studies have shown that students' ability to represent mathematical images is still low. Therefore, in this study, researchers conducted research on the abilities represents a mathematical visualization. Ariawan (2017) and Trisnawarni and Yuniata (2021) found that most students had difficulty expressing and visualizing their thoughts, and students had difficulty visualizing problems. As a result, students tend to be unable to solve the problem. This can happen because the learning process does not stimulate students' ability to express problems related to pictures.

The importance of visual thinking in mathematical discovery is graphically illustrated in Hadamard's work (Thornton, 2001), which tells about their thinking processes when solving problems or investigating new ideas. He identified a remarkable consistency in the way in which leading mathematicians used pictures to develop their minds, only resorting to more formal algebraic conventions when they wanted to communicate their results with others.

Visual thinking becomes an integral part of problem solving, for example using diagrams to explain, document, calculate or show the steps involved in reaching a solution. Visual representations can play a role in communication, for example using diagrams and visual forms to convey information, represent data and show relationships.

Seeing the description above, it can be concluded that the ability to visual thinking mathematically was an important part of problem-solving. Meanwhile, problem-solving was at the heart of the teaching and learning process of mathematics, as stated in the mathematics learning curriculum, which states that the core of the mathematics learning process was problem-solving. Darmadi and Handoyo (2016) revealed that one of the reasons for using visual thinking in learning mathematics was because visualization can provide a simple, easy, flexible, and very powerful approach to developing mathematical solutions and problem-solving as well as in the process of making connections.

The importance of visual thinking in mathematical discovery was graphically illustrated in Hadamard's work (Darmadi & Handoyo, 2001), which tells about their thinking processes when solving problems or embracing new ideas. He identified a remarkable consistency in the way in which leading mathematicians used pictures to develop their minds, only resorting to more formal algebraic conventions when they wanted to communicate their results with others. Therefore, learning mathematics is very important to improve visual mathematics skills so that mathematics teachers recognize and develop them.

In the process of improving visual mathematical abilities, a learning process is needed to stimulate student activity. One of the effective learning methods that can be used is project-based learning. Project-based learning is a learning model in which learning is to design, practice, and complete project- or product-based learning tasks. Project-based learning (PjBL) is useful in developing and involving students in continuous learning, because students need to actively make productions, reports, and presentations, this needs to be done during the learning process (Husamah 2015).

The project-based learning model was a learning model that includes all student-centered activities, where students carry out problem-solving activities through inquiry, design, and problem-solving processes. The teacher's role in project-based learning is to monitor and guide student activities (Priatna et al., 2022; Erdoan et al., 2016). The ability to think of students when working on a project requires a learning approach, including the STEM approach. The STEM-based PjBL model emphasizes contextual learning through complex activities such as discovery, learning, collaboration, and production of a product (Sari & Priatna., 2020; Ambarwati et al., 2015). In STEM, students must solve real-world problems and engage in unspecified tasks to achieve well-defined outcomes (Han et al., 2015).

Based on some of the explanations above, it can be concluded that students' visual mathematical abilities can be improved through PjBL-STEM, the problems posed are problems that are close to the students' daily activities (real-life context), prioritizing the process of student work that is informal by continuing on formal stage. These characteristics can be found in PjBL-STEM learning which guides students more to discover the concepts they were learning for themselves by the problems they are manipulating and related to previous experiences students have.

Looking at the PjBL-STEM learning process has everything to do with students' mathematical visualization abilities of logically existing problems. Therefore this study aims to see the effect of PjBL-STEM learning in learning mathematics to improve high school students' mathematical visualization abilities.

METHOD

This study used a quasi-experimental where the subjects were not randomly grouped, but the researchers accepted the conditions of the subjects as simple (shadish et al., 2002). In this study, two classes were used as samples, namely the experimental class which received STEM Project-Based Learning, and the control class which received conventional learning. In this study, Project-based Learning STEM learning and conventional learning as independent variables, and students' mathematical visual abilities as the dependent variable.

Non-Equivalent Control Group Design was used for this study (Sari et al.,i, 2022). The sample for this research was students of class X A and X B at a high school in Bandung Regency for the 2021/2022 academic year. Purposive sampling was used in this study to collect data. In this study, a test instrument was used in the form of students' visual mathematical ability to measure and understand a given mathematical problem before and after treatment. This mathematical visual ability test is arranged in the form of an essay on basic trigonometry material.

RESULTS AND DISCUSSION

Quantitative data were obtained through mathematical visual thinking tests at the beginning and end of learning, as well as completing a mathematical reliability questionnaire. The data was obtained from 66 students, consisting of 34 Experiment class students who received PjBBL-STEM learning and 32 control class students who received conventional learning. The following is a description of the results of the study.

The discussion of the results of this study is based on the factors observed and found in the research. The following is an overview of the mathematical visual thinking ability data obtained through the pre-test and post-test, and the N-gain in the experimental class and the control class.

Table 1

Statistik Deskriptif Kemampuan *Visual Thinking Mathematis*

Score	Experiment				Control			
	N	$\bar{x}$	SD	%	N	$\bar{x}$	SD	%
Pre-test	34	3,50	2,97	17,5	32	4,18	3,77	20,9
Post-test	34	12,32	4,67	61,6	32	9,78	4,37	48,9
N-gain	34	0,53	0,26		32	0,35	0,24	
Ideal Maksimum Score = 20								

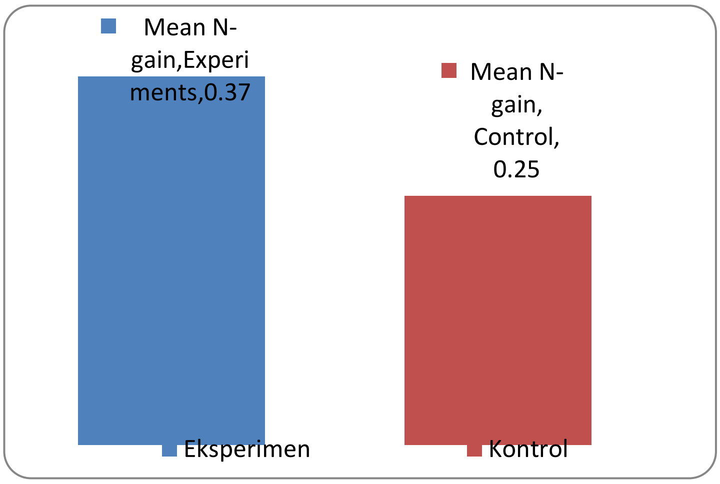
Based on Table 1 above, the pre-test average for the experimental class is 3.50 and for the control class is 4.18. The pre-test mean of the two classes was relatively the same before being given treatment. The percentage score is obtained from the quotient of the average score with the ideal score multiplied by 100%. The average post-test score for mathematical visual thinking skills in the experimental class was 12.32 or 12.70% higher than the control class with a post-test average of 9.78. Meanwhile, the average N-gain for visual thinking mathematical ability in the experimental class was 0.53 with a moderate improvement classification. For the control class, it was 0.35 with a low improvement classification. This is in accordance with the results of Muflihatussyarifah (2016) and Aini et al., (2019) which states that students' visual mathematical abilities that students learn through innovative learning will produce maximum visual mathematical abilities. The summary results of the N-gain mean of students' mathematical visual thinking skills in the experimental class and control class are presented in the following table.

Table 2

N-gain Classification and Means Mathematical Visual Thinking Ability

Class	Mean N-gain	Classification
Experiment	0,53	Medium
Control	0,35	Medium

From Table two above, a diagram can be made to compare the average N-gain scores for students' mathematical visual thinking abilities in the experimental class and the control class.



Picture 1
Comparison of Mean N-gain Scores
Mathematical Visual Thinking Ability

From Figure one above it can be seen that students who receive PjBBL-STEM learning (experimental class) have a greater average N-gain score than students who receive conventional learning (control class). Classification of the N-gain scores for the experimental and control classes was in the moderate category. However, to ensure whether it was true that the increase in the mathematical visual thinking abilities of students who receive PjBBL-STEM learning was better than students who receive conventional learning, it is necessary to carry out further statistical tests.

The statistical test needed to prove the hypothesis which states "the increase in the mathematical visual thinking skills of students who receive PjBBL-STEM learning is better than students who receive conventional learning" namely the difference test of the mean N-gain score, previously the prerequisite tests for normality and homogeneity have been carried out, and the results obtained for both classes are normally distributed and have a homogeneous variance.

The normality test of the N-gain score was calculated using the Kolmogorov-Smirnov test with the help of the SPSS 20 program. The summary results of the normality test are presented in the following table.

Tabel 3
Uji Normalitas Skor N-gain

Kelas	Kolmogorov-Smirnov			Kesimpulan
	Statistic	Df	Sig.	
Eksperimen	0,132	34	0,144	Data Berdistribusi Normal
Kontrol	0,076	32	0,200	Data Berdistribusi Normal

From Table 3 above it can be seen that the N-gain scores for the mathematical visual thinking abilities of the experimental and control class students have a Sig value. > $\alpha = 0.05$

so that H0 is accepted. This shows that the N-gian score data for the mathematical visual thinking abilities of the experimental and control class students are normally distributed.

To test the homogeneity of the variance of the N-gain score, Levene's test was used with the help of the SPSS 20 program at a significance level of α = 0.05. A summary of the homogeneity test calculations is presented in the following table.

Tabel 4
Uji Homogenitas Varians Skor N-gain

Levene Statistic	df1	df2	Sig.	Kesimpulan
0,051	1	64	0,823	Variansi homogen

From Table 4 above it can be seen that the N-gain score shows the value of Sig. greater than α = 0.05 which is equal to 0.823, so that H0 is accepted. This means that the N-gain scores for the mathematical visual thinking abilities of the experimental and control class students come from a homogeneous variance.

So to prove that the N-gain score of the students' mathematical visual thinking skills in the experimental class is better than the control class, a test for the difference in the mean N-gain score was carried out using an independent sample t-test. The following summarizes the results of the test for the difference in the mean N-gain score at the significance level α = 0.05.

Table 5
N-gain Mean Score Difference Test
Mathematical Visual Thinking Ability

t-test for Equality of Means			Information	Conclusion
T	Df	Sig. (2-tailed)		
2,972	64	0,004	HO rejected	There were differences

From the results of the independent sample test above, the p-value or Sig. (1-tailed) that is 0.00 < α = 0.05. This shows that H0 is rejected, meaning that the increase in the mathematical visual thinking abilities of the experimental class students is better than that of the control class students. Thus it is proven that the hypothesis states that the increase in the mathematical visual thinking abilities of students who receive PjBL-STEM learning is better than students who receive conventional learning (Sari et al., 2022). These results illustrate that PjBBL-STEM learning has proven to make a good contribution to developing mathematical visual thinking skills. So it can be concluded that PjBL-STEM has a better role in developing mathematical visual thinking abilities.

PjBL-STEM is a learning that begins with problems that students can explore to get a concept, so learning with PjBL-STEM learning places students on ways to solve a problem through the process of working on a project (Priatna & Sari, 2022; Husamah, 2015; Wahyudi et al., 2018). In PjBL-STEM learning the teacher designs a project so that students may not find a solution with one step of completion, but requires several stages to complete it.

The stages designed in this study are the stage of giving problems in the form of giving project assignments, collecting data or information related to the problem, making assumptions and testing these assumptions, producing a product, presenting the findings, and

finally concluding the findings. Through this project-based learning process, students can develop their curiosity, so that they will try to find solutions to the problems they face with full confidence that they can solve them if they try, and believe that what they find is a logical answer (Priatna et al., 2022). The PjBL-STEM learning that is implemented also provides opportunities for students to be active during the learning process.
Student activity can be seen when they are involved in solving problems on student activity sheets to do project assignments, in group discussions, and in class discussions. Based on the concept of Piaget with regard to activity (Sadiq, 2009) which reveals that a person's cognitive development is influenced by activity, both physical activity and logical-mathematical activity and social transmission. Therefore it is very appropriate when learning the teacher creates a learning environment that provides opportunities for students to carry out mind-on and hands-on activities that can construct their knowledge based on their experiences. (Walker et.al, 2011).

From the results of the study, it can be seen that the learning model factors have a significant influence on students' mathematical visual thinking abilities. By giving project assignments, students are helped to understand mathematical concepts, because so far students have received direct explanations from teachers which sometimes students have to take for granted without being allowed to explore these concepts (Ariawan, 2017; Ambarwati, 2015). One example is discovering the concept of trigonometry in determining the height of a flagpole. When students learn about the concept of trigonometry, students just take it for granted based on the teacher's explanation. However, through giving this project assignment, students can discover the basic trigonometry concepts for themselves with the help of the teacher. By providing problems that are close to students' lives, it turns out that students can discover the concept of trigonometry and can provide other examples or other cases that can facilitate students to get the concept.

CONCLUSION

Based on the formulation of the problem and the results of the research as well as the discussion of the results of the research as described, the conclusions obtained are: (1) In general the application of the PjBL-STEM learning model has been able to improve students' mathematical visual thinking abilities. (2) The increase in students' mathematical visual thinking using the PjBL-STEM learning model is significantly better than learning using conventional learning models.

Referring to the research results as described above, the implications of these results include the application of the PjBL-STEM learning model that can be used as an alternative learning at the high

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