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ENHANCING STUDENTS' UNDERSTANDING OF THE MEAN CONCEPT THROUGH PROBLEM-BASED LEARNING ASSISTED BY GEOGEBRA: A QUASI-EXPERIMENTAL STUDY

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Abstract

This study aims to evaluate and describe students' mathematical comprehension skills on the concept of mean through problem-based learning (PBL) assisted by GeoGebra. This study uses a quasi-experimental quantitative method with a non-equivalent pretest post-test control group design. The research sample was 55 students consisting of 26 students in the experimental class and 29 students in the control class. Data collection was carried out using a mathematical comprehension ability test consisting of 5 description questions. The data was analysed using IBM SPSS 29.0. The results of PBL assisted by GeoGebra research have a positive effect on improving students' mathematical comprehension ability on the mean concept. This shows that PBL with the help of GeoGebra can improve students' comprehension of the concept of mean and make learning more interactive and interesting, and then can be an alternative learning model. When researchers with the same theme read the results of this study, they can consider them as input for further research.

Keywords: Assisted GeoGebra, Problem-based learning, Understanding of the mean concept.

1. Introduction

The concept of mean in statistics is a measure of data centring that is very important to study [1].The mean describes the middle value of a data set and is often used in various statistical analyses [2]. A solid understanding of the mean allows for more accurate and informative data analysis, which is critical in fields such as economics, education, and scientific research. Therefore, the ability to mathematically understand the concept of the mean must be strong so that data analysis and interpretation can be carried out well [3]. The importance of the concept of mean must be taken into consideration in learning.

There are several learning approaches including Concrete Pictorial Abstract (CPA) [4], and Concrete Representational Abstract (CRA) [5]. In this approach, material is presented in stages starting from things that are contextual to everyday life, then expressed in iconic/visual form, and finally given in symbolic form. The process of presenting this material aims to ensure that students who are not yet ready for abstract thinking processes do not experience obstacles in learning mathematical concepts. One example of the stages of presenting mean material based on this approach is depicted in the form of a mathematical iceberg (Fig. 1).

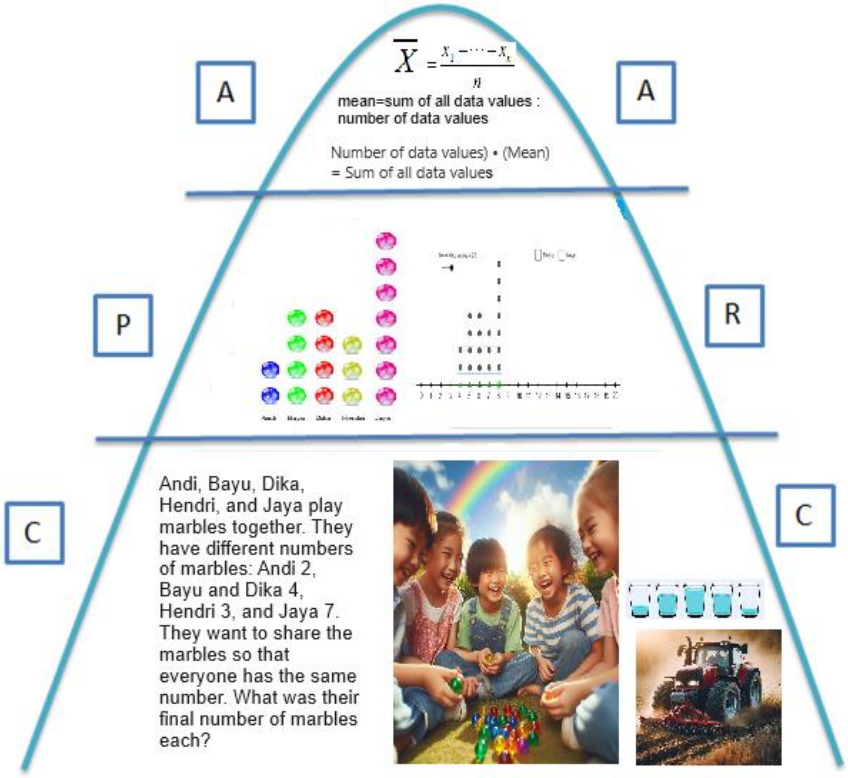

Fig. 1. Iceberg for the concept of mean.

Building meaningful concepts starting from concrete to abstract, can help develop a deep understanding of meaning [6]. Thus, students can more easily apply

these concepts in various real situations and other statistical data analysis [7-10]. To be able to convey this concept, the right learning model must be chosen. In this research, the Problem-Based Learning (PBL) and Discovery Learning (DL) models were chosen because based on previous research [11-16], these two models can help improve mathematical understanding abilities [17-19].

To help bridge from concrete to abstract concepts, GeoGebra is used as a tool, because GeoGebra has been proven to be a tool for improving students' mathematical abilities [20-24]. An example of an applet used in learning the concept of mean is shown in Fig. 2. This applet is used so that students actively participate in the learning process, conduct their experiments, and get instant visual feedback, all of which contribute to more effective and engaging learning [25]. Thus, students' mathematical understanding of the concept of mean is strong.

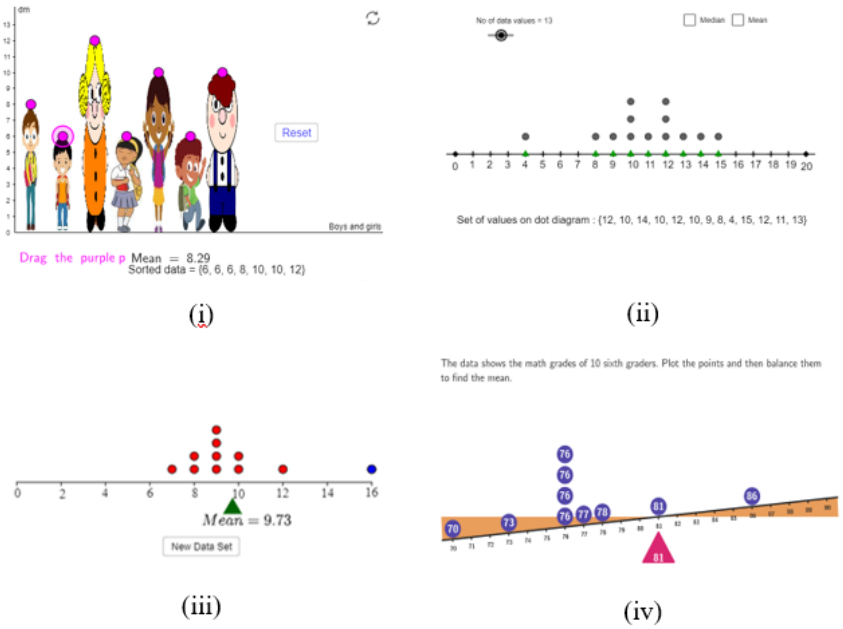

Fig. 2. GeoGebra applets used in learning.

This research aims to analyse and describe the effectiveness of using PBL models assisted by GeoGebra in improving students' mathematical understanding of the concept of the mean. Through this approach, it is hoped that students can better understand the concept of meaning in-depth and application thus that when they become teachers, they can provide correct concepts and are easy for students to understand [26]. The novelty of this research lies in the integration of PBL models with the GeoGebra application on the concept of mean, which has not been widely applied in previous research as seen in Fig 3 which shows the Scopus indexed research map.

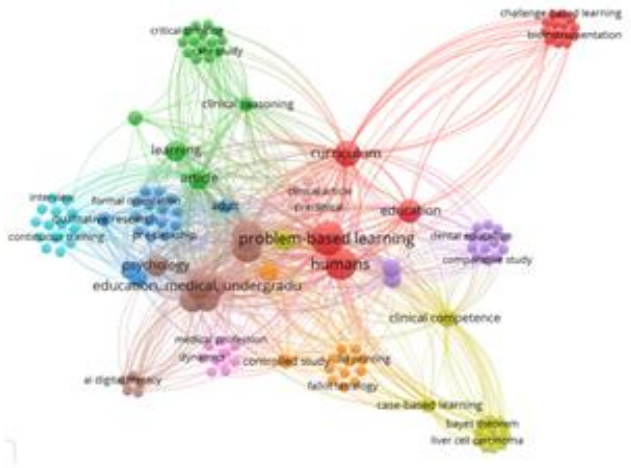

Fig. 3. The network visualization of emerging keywords on PBL.

2. Method

The research method was quantitative quasi-experimental with a non-equivalent pretest-posttest control group design. Two classes were involved in this research, one group as an experimental class, namely students who studied using the PBL model, and one group as a control class, namely students who studied using the DL model selected using a purposive sampling technique at one of the universities. high in Bandung, Indonesia. The research sample was 55 students consisting of 26 experimental class students and 29 control class students.

Data collection was carried out using a comprehension ability test consisting of 5 descriptive questions designed with indicators from Skemp, including applying formulas in simple calculations and do calculations algorithmically and associating one concept with another. The data analysis used IBM SPSS 29.0 software to perform independent sample t-tests and paired sample t-tests. Detailed information regarding t-tests is explained elsewhere [27].

3. Results and Discussion

Research data obtained from the field is in the form of pretest and the post-test results of students' mathematical understanding ability on the concept of mean through PBL with the help of GeoGebra and DL with the help of GeoGebra. In summary, the calculation results can be presented in Table 1, which shows the maximum and minimum values, the average value, and the standard deviation of each group of data. Both groups had almost the same pretest average scores, indicating that the initial abilities of the two groups were relatively balanced before treatment. After treatment, both groups showed a significant and almost the same increase in average values. This shows that both learning methods (PBL and DL) are equally effective in improving students' mathematical understanding abilities.

The same average N-Gain value in both groups shows that the increase in mathematical understanding due to learning is the same between PBL and DL. The small standard deviation shows the consistency of improvement in each group. Overall, based on descriptive analysis, it shows that the PBL and DL methods

assisted by GeoGebra are effective in improving students' mathematical understanding abilities. The improvements produced by the two methods are relatively the same, both in terms of post-test scores and N-Gain.

Table 1. The description of students' understanding ability data.

Class	n	Pretest				Postest				N-Gain	
		Min	Max	$\underline{x}$	SD	Min	Max	$\underline{x}$	SD	$\underline{x}$	SD
PBL	26	30	65	46.8	10.9	55	90	73.7	11.2	0.5	0.1
DL	29	30	60	47.2	8.1	50	90	73.3	9.9	0.5	0.1

The assessment of students' ability to understand the mathematical concept of mean for both groups was conducted by performing hypothesis testing with the help of SPSS, specifically through an independent sample t-test on the post-test data. The test results can be seen in Table 2. which shows the significance value (Sig.) of Levene's Test is 0.332 > 0.05, meaning that the assumption of the equality of variance is met, in other words, the two groups are considered to have the same initial mathematical understanding ability.

The significance value (Sig. 2-tailed) of the t-test is 0.894 > 0.05. This means that there is no statistically significant difference between the means of the two groups being compared. In other words, there is not enough evidence to say that the means of the two groups are different.

Table 2. The results of the independent sample t-test.

Equal variances assumed	Levene's Test for Equality of Variances	t-test for Equality of Means
	Sig.	Sig. (2-tailed)
Posttest	0.332	0.894
N-Gain Score	0.516	0.647

To find out the difference in the increase of students' ability to understand the mathematical concept of mean between those who studied with PBL and DL, we conducted a hypothesis test using SPSS, specifically by performing an independent sample t-test on the N-Gain Score data. The calculation results can be seen in Table 2, which shows the significance value (Sig.) of Levene's Test is 0.516 > 0.05, meaning that the two groups are homogeneous.

The significance value (Sig. 2-tailed) of the t-test is 0.647 > 0.05. This means that there is no statistically significant difference in the increase of students' mathematical understanding of the mean concept between the averages of the two groups being compared. These results follow the results of the descriptive analysis presented in Table 1 which shows that the average and standard deviation of N-Gain scores for both groups are the same.

Next, conducted a paired sample t-test using SPSS to determine whether students' ability to understand the mathematical concept of mean increased in both PBL and DL classes. The test results based on the paired samples test output, the sig (2-tailed) value for the PBL class and DL class is 0.000 < 0.05. This indicates that there is an average difference between the ability to understand the mean concept before treatment and after treatment, meaning that the use of PBL and DL has an effect in increasing students' ability to understand the mean concept. Thus,

these two learning models are effective in helping students understand the concept of meaning better after receiving appropriate treatment.

These results are in line with various studies that show the effectiveness of PBL and DL models in improving students' mathematical understanding. Research on the integration of different pedagogical approaches, such as project-based and problem-based learning, can offer students enhanced opportunities to engage in exploratory activities that promote a deeper and more meaningful development of their statistical thinking skills [28]. Discovery learning models integrated with technology applications can improve students' skills [29].

Thus, the GeoGebra-assisted PBL and DL learning model not only supports students' understanding of mathematical concepts but also has a positive impact on students' critical thinking, problem solving and statistical thinking abilities, which ultimately improves overall learning outcomes [30]. This study also gives ideas in the teaching and learning of mathematics, as reported elsewhere [31-37].

4. Conclusion

The PBL and DL learning methods are effective in improving students' mathematical understanding, especially the concept of mean. The results of the descriptive analysis show that both methods provide a significant and almost the same increase in average values after treatment. The same average N-Gain value and small standard deviation show the consistency of ability improvement in each group. In addition, the results of Levene's Test and t-test statistical tests showed that there was no significant difference in students' initial mathematics abilities between the two groups.

There was also no significant difference in the increase of the ability to understand the mean concept after treatment. The paired samples test also indicated a significant average difference between before and after treatment, strengthening the evidence that PBL and DL had a positive effect on increasing students' mathematical understanding of the concept of the mean. This research confirms that both learning methods are effective in helping students improve their mathematical understanding of the concept of meaning.

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