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Research Article

The Effectiveness of Web-based Inductive Learning Assisted on GeoGebra

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Abstract.
This research used web-based inductive learning that facilitated plane geometry learning, where the learning was carried out online. It was hypothesized that students could learn the concept of plane geometry better when students were involved in the induction process with the help of GeoGebra software. They did explore with GeoGebra software to form several examples of the concept, testing the patterns that existed in the examples, and generalized the findings into new knowledge. With the help of the web and GeoGebra software, students could carry out their own learning and make their own discoveries. To test the effectiveness of web-based inductive learning, two classes were involved in the research, they were students of the Mathematics education study program Faculty of Teacher Training and Education, University of Bengkulu who took plane geometry class in the even semester of the 2021/2022 academic year as many as 68 students. This research was a quasi-experimental research with a post-test-only control group design. The instrument used for measurement was a description test. Based on the data analysis, it was found that the learning outcomes using web-based inductive learning assisted on GeoGebra were better than those using the expository method.

Keywords: web, inductive learning, geogebra

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1. INTRODUCTION

The plane geometry learning that had been carried out so far was inseparable from the needing to develop and train students' skills in reasoning and understanding comprehensively a concept. Learning that was carried out online must also continue to develop students' thinking and reasoning abilities, especially in the plane geometry course. Previous research had revealed that developing mathematical abilities, reasoning, was an important part of learning science and mathematics [1–3]. Reasoning was an activity that needed in inductive learning. Inductive learning was learning that involved

reasoning as an action to use reason in drawing conclusions from certain premises that involve specific reasoning to a general form [4].

Reasoning ability helped students in analysing and understanding new situations they faced to form new knowledge by connecting the knowledge they already have. The involvement of reasoning in inductive learning could be seen in learning activities, where students could carried out activities in many aspects as described [4] by making logical assumptions, explaining their thoughts, reaching conclusions and defending their conclusions. Inductive learning was needed that was closely related to reasoning because reasoning skills were important to improve thinking skills which should be the main goal of education [5]. Many problems were found in face-to-face learning in developing students' mathematical thinking skills. The fact shown that mathematics learning outcomes in universities in terms of mathematical ability were still low [6] and students are still having trouble getting and processing mathematical ideas to solve problems [7]. For this reason, in online learning today, technology-based activities were needed that could directed students to develop their thinking and creative abilities. The used of technology could provided a higher motivational power to explore concepts, especially for students in the 21st century [8, 9] and technology played an important role in the development of the learning process [10].

Learning by utilizing technology could be done by designing inductive learning using a web-based student worksheets. The web-based student worksheets used contained an inductive process. The inductive learning process included the process of transferring specific forms to general ones, namely generalizing and obtaining broad rules based on experience [11]. The experience referred to in inductive learning here was analysing several conditions or problems which were then analysed to obtain general conclusions on a concept. Inductive learning made students more active both individually and groups in developing knowledge together [6]. Inductive learning that involved inductive reasoning allowing one to detect regularities, rules or generalizations and vice versa, detect irregularities [12].

This research was carried out in an online learning process, inductive learning activities were contained in a web-based Student worksheet that could be accessed online by students wherever and whenever they were. Accessing web-based Student worksheets could used laptop, tablet or smartphone. The web-based student worksheets used in this inductive learning was assisted on GeoGebra software on the plane geometry course. Plane geometry was a prerequisite material for geometry and transformation geometry. It was found that there were still many students who had difficulty in geometric thinking [13, 14] Students still had difficulty getting and processing mathematical

ideas to solve problems, therefore preparation was needed for students to understand geometry course optimally [15]. Familiarize students to process known information, so that it became an idea and then develops into new knowledge. Such a learning process required directed involvement of students in the form of experience. Experience would provided skills and knowledge that would remain in the student's memory. Plane geometry course involved a lot of image construction and abstract concepts. In order for students to understand the course well, technology assistance was needed in their learning. The maximum use of technology would had good impact in the form of a learning experience. For plane geometry course, the technology that could be used was GeoGebra software.

GeoGebra software had been used as a tool that could helped lecturers and students in carrying out learning effectively [16] and GeoGebra was useful for mathematics learning activities related to images and graphics because of its dynamic nature [17]. The results shown that the GeoGebra device was useful as a visualization medium in understanding mathematical objects [18]. GeoGebra was used as a medium to describe the truth of graphs or mathematical objects [19]. Previous research had used GeoGebra software in mathematics learning only to the extent of simulation, and using GeoGebra software only through guided guidance by lecturers. But the used of GeoGebra software in inductive learning would provided wider opportunities for students to explore GeoGebra software into applications that directed students to reason inductively. GeoGebra could provided an environment for students to work individually or collaborate in exploring mathematical problems.

The problem of geometry course and the limited exploration activities of the GeoGebra software would be bridged through inductive learning activities. Because in inductive learning students were asked to find and construct information to determine the basic patterns and principles [20]. Inductive learning with the help of technology could be done through a website, where students accessed a website in which there was a student worksheet. The inductive learning process was directed by guiding students to explore using GeoGebra software to form several examples of concepts, test patterns contained in examples, and generalize findings into new knowledge. All inductive processes were still controlled and observed by the lecturer, because the inductive processes carried out by students were recorded in the database. The purpose of this research was to determine whether the learning outcomes of applying web-based inductive learning assisted by GeoGebra on plane geometry course were better than the results of learning plane geometry with expository learning in online learning.

2. RESEARCH METHOD

This research was a quasi-experimental research with post-test only control group design model. To determine the effectiveness of web-based inductive learning assisted on GeoGebra, two classes of research were taken as samples. The first class as the experimental class and the second class as the control class. The experimental class was given treatment, namely web-based inductive learning with the help of GeoGebra, while the control class was treated using expository learning. The sample in this research was undergraduate mathematics education students as many as 68 students who took the plane geometry class in the academic year 2021/2022. The instrument used was a field geometry learning result test that was given to students after attending class with actions according to each class

Data analysis used t-test which was analysed using SPSS software. The hypothesis of this research was that student learning outcomes with web-based inductive learning assisted on GeoGebra were better than student learning outcomes using expository learning on plane geometry course. Formally (H0) and hypothetically (H1) were as follows:

$H0 : \mu1 = \mu2$ $H1 : \mu1 > \mu2$ The test criteria was that H0 was accepted if the SPSS output results for the t-test with sig $>$ 0.05. In addition to testing with the t test, descriptive statistics were also calculated, namely the average value, standard deviation and skewness score, used to determine which learning outcome was better after the two classes were treated according to their respective actions.

3. RESULTS AND DISCUSSION

The experimental class received action in the form of web-based inductive learning assisted on GeoGebra, while the control class received action in the form of expository learning. Both classes carried out online learning on the plane geometry course. After the two classes carried out learning for 6 weeks according to their respective actions, a learning outcome test was carried out. Analysis of learning outcomes data could be explained as follows:

3.1. Learning Outcome Analysis

Each student in the experimental class got a username and password to access the web on the www.geometri.effie.info page to carry out inductive learning with the help of

GeoGebra. Synchronous meetings via zoom were also held to collaborate and discuss the work obtained on the web page. The expository class was carried out synchronously using the zoom application by applying expository learning. The experimental class explored using GeoGebra software to form several examples of concepts, the examples that had been obtained were tested for patterns and generalized the findings into new knowledge. The results of the learning test of the two classes after being given treatment showed that the experimental class and the control class came from a normally distributed variance.

The next test was the average test of learning outcomes using the t-test. The test results using SPSS showed the output value of Sig. (2-tailed) which is 0.000 less than the level of Sig α = 0.005 so that H0 was rejected. It meant that there was a difference in the average student learning outcomes with web-based inductive learning assisted on GeoGebra and student learning outcomes with expository learning. To know which one was the better learning, descriptive statistical analysis was conducted. The following was the SPSS output for descriptive statistical data for the two classes, which could be seen in table 1.

TABLE 1: Descriptive statistic for learning outcome test.

Class	Number of Students	Min Score	Max Score	Average	Score Skewness
Experiment	34	14	98	78.38	-2.547
Control	34	22	78	60.03	-1.027

The average learning outcome for the experimental class was 78.38 while the control class had an average learning outcome of 60.03. From the average learning outcomes, the experimental class was greater than the control class average, it meant that the learning outcome of web-based inductive learning assisted on GeoGebra was better than expository learning. Judging from the skewness score of the experimental class that -2.547, it showed that descriptively the collection of scores towards a negative sloping curve compared to the control class. This illustrated that the test scores of learning outcomes with web-based inductive learning assisted on GeoGebra tended to gather high scores. The distribution curve of test scores for the experimental class and the control class could be seen in Figure 1.

In the experimental class, the distribution of students who got high scores showed a significant increase at the same level, it was seen that students gathered more at scores of 60-100. Meanwhile, in the control class, scores still gathered at a value of 20-60, although high scores were also found in the control class. control class clustered in the value of 60 - 78. Based on statistical tests showed that web-based inductive learning

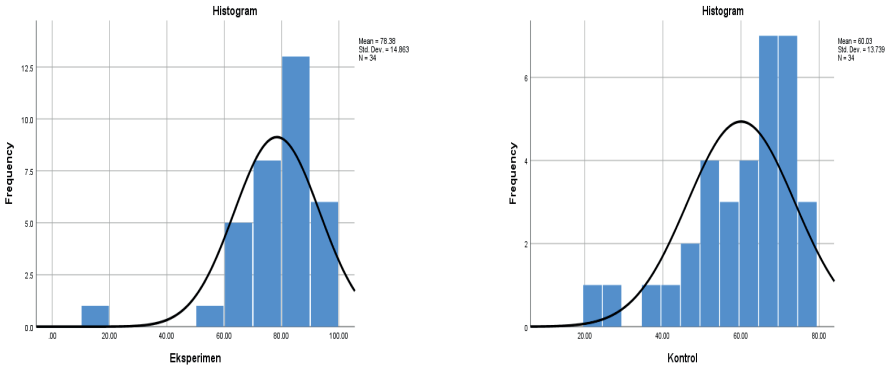

Figure 1: Distribution of student learning outcomes from experiment and control classes.

assisted on GeoGebra was better than expository learning, activities in learning activities greatly affect the results of learning tests on plane geometry course whose learning was carried out online.

3.2. Analysis Web-Based Inductive Learning Assisted on GeoGebra

Inductive learning carried out online through the learning web directed students to develop their exploration and analysis skills. The web had designed a student worksheet that directs students to find the concepts. The research findings revealed that there were still students who did not have the right ability about the role of theory in scientific investigation [5]. The problems found, directed this research to develop students' abilities in connecting the concepts they had to find new knowledge. The experimental class carried out activities through the web where all student activities could be controlled and known by the lecturer. Students started activities according to the activities that had been designed on the learning web. Inductive learning web began with students doing GeoGebra exploration to find examples of concepts. Students were given the opportunity to explore their ability to use GeoGebra so as to produce applications that could specifically be used to collect data needed to find concepts in general.

A student-made application to demonstrate the definition of a circle, starting with specific examples. The example begins by determining 2 points, namely points A and O, connecting the two points, then shifting point A around point O, so that the distance from point A to O remains. Each shift of point A was called point A1, A2, A3, ..., An. The following was an example of an application produced by students in showing the definition of a circle which could be seen in Fig. 2.

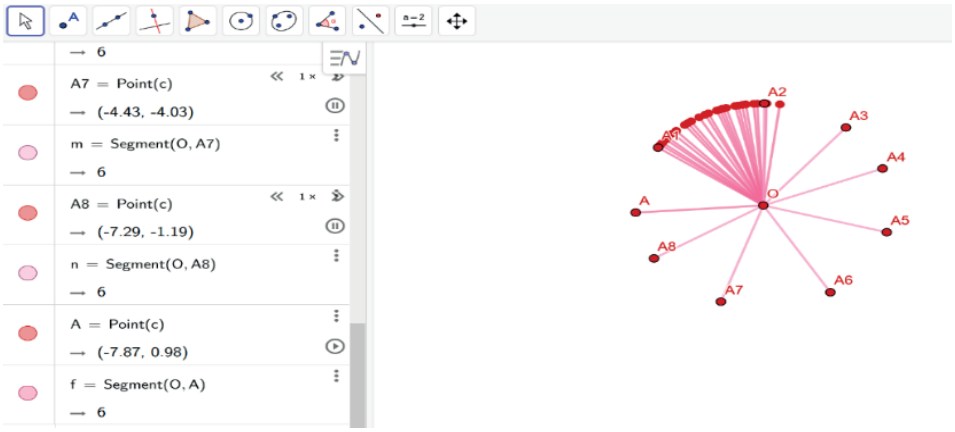

Figure 2: GeoGebra application for circle definition example 1.

Figure 2 was used by students to determine the distance from point An to O, from example 1 students had found some distances between point o and point An. It could be seen from the GeoGebra output. The length of the segment point O to A1, the length of the segment O to A2, ... the length of the segment O to A8 was all the same, it was 6. Because there were still other points that had the same length as point O, the GeoGebra application was continued until the length of the segment O to point An was found. Figure 3 below showed many points that had the same distance from point O.

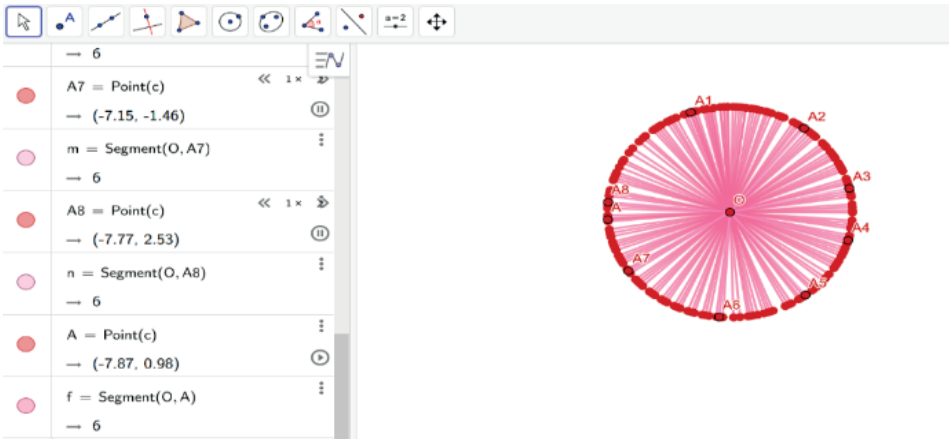

Figure 3: GeoGebra application for circle definition.

Figure 3 showed the number of points that could be formed from point O to point An so that they had the same distance. After all the points that had the same distance from the point O were gathered, then a circle was formed. Special cases starting from 7 points that had the same distance from point O, then proceed to other points that had the same distance from point O directed students to test the pattern formed in the application and match the data on the GeoGebra output to draw conclusions about the

definition of a circle. The following was an example of a conclusion made by students on a learning web page, which could be seen in Figure 4.

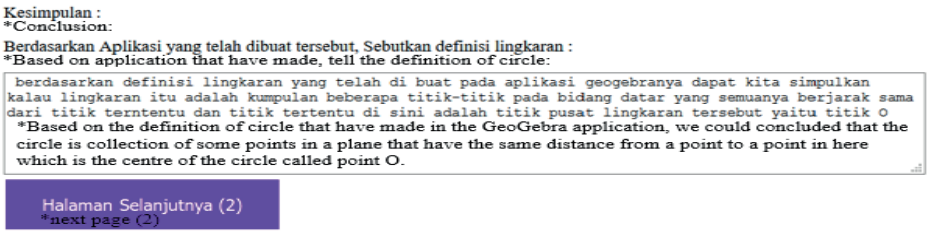

Figure 4: Example of generalize the concept activity.

Exploration activities in GeoGebra to carry out inductive learning made students more interested in learning, because students were motivated to solve problems given through the opportunity to explore and analyse the data obtained in the application and the mathematical concepts that they had. Supported by findings that showed computers in presenting mathematical content could provided directing feedback to students to engage better in deepening understanding of the concept [21].

The induction process began by processing the information that students got on the output of the GeoGebra application that they made. Developing the ability to think inductively could developed significantly not only in face-to-face learning but also in computer-based environments [22, 23] Lecturers could designed inductive learning in an interesting way so that virtual activities in online learning were still able to develop students' creativity and thinking skills. The inductive learning process in testing patterns and generalizing concepts could also be seen in the application example determining the length of the tangent line to the inner circle, shown in Figure 5.

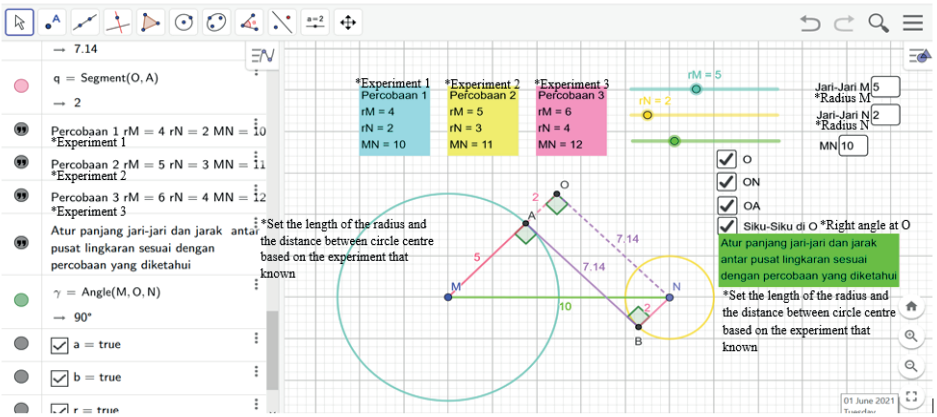

Figure 5: The process of testing the pattern and generalizing the concept.

The resulting application directed students to find the formula for determining the length of an internal common tangent. It started by finding the pattern of the three

experiments carried out. In Figure 5 students could determine the desired length of each finger by uploading it to the application. GeoGebra output was obtained which shows the length of the tangent line. Through three or more experiments conducted, students were asked to find patterns and related them to the concepts they already have. Using the concept that had been previously owned, it was the Pythagorean theorem, students found patterns and generalize the concept of measuring the length of an internal common tangent. The patterns found by students must had clear and correct arguments. Argumentation referred to findings and data that match the desired concept [23]. Concepts would also be obtained based on the obtained regularities and lead to a more general form of a concept. The activities that had been described were the reasons that web-based inductive learning assisted on GeoGebra provided better learning outcomes than expository learning.

4. CONCLUSION

Based on the research and discussion that had been described in the previous sub-chapter, it could be concluded that learning outcomes using web-based inductive learning assisted on GeoGebra were better than learning outcomes using expository learning on plane geometry course in online learning in the Mathematics Education Study Program, Faculty of Teacher Training and Education, University of Bengkulu. The used of web-based inductive learning could be expanded by improving other mathematical abilities according to educational standards.

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