The effect of dynamic mathematics software on mathematical problem solving ability

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Abstract. Mathematics is one of the fields of science that is very important for humans because all science is related to mathematics. One of the skills that should be learned and developed in mathematics is mathematical problem-solving ability. Problem-solving ability is highly needed because humans are always used in everyday life, both in education and daily life. In fact, students' problem-solving abilities are lacking. This is because mathematical problems created by teachers are not based on indicators of problem-solving ability. Triangle is an important material of two-dimensional figures in elementary school. Teachers need to explain the basic concept of a triangle so that students can master a more difficult concept of a triangle. Dynamic mathematics software can help students grasp the concept of triangles. This study used a quantitative method. This study is a comparison between classes using Hawgent and using conventional methods. The subjects in this study were 72 seventh-grade students in Cianjur, Indonesia. Data were collected based on the results of the pre-test and post-test problem-solving ability. Based on the study results, the class using Hawgent is more good than the class that using the traditional method. Hawgent has been proven to help students understand triangle material.

1. Introduction

One of the mathematical skills that should be learned by elementary school students is the problem-solving ability [1]–[3]. Problem-solving is the ability to analyze the relationship between symbols, information, and patterns [4]. It is very urgent because elementary school students would be able to improve their mathematical knowledge and ability when they solve questions that require problem-solving ability [5]. Therefore, the problem-solving ability is one of the objectives of mathematics lessons. Important steps in problem-solving are understanding a problem, analyzing, and rechecking the answers. Problem-solving indicators include (1) understanding the problem; (2) devise a plan; (3) carry out the plan; and (4) evaluation [6]. Mastery of basic concepts is one of the keys to success in developing the problem-solving ability of students. Therefore, each teacher must use a learning method that is centered on the basic concept of material. However, in fact, teachers still often use expository methods to explain material in the classroom [7]–[9]. Students only listen and note the formulas and do practice questions. A teaching method that does not incorporate students to think will deteriorate students' problem-solving ability as students only memorize formulas to solve questions. Triangles are junior high school grade 7 material [10]. This chapter takes a lot of proof about the relationship of triangles and rectangles [11], from which the formula of the base multiplied by the height divided by two and also proof of why the angles in a triangle are 180 degrees. When studying the triangle chapter, if the teacher does not explain the proof from which the initial angle of the triangle is 180 degrees and only explains that the total of the corners in the triangle is 180 degrees and then gives a lot
of practice to the student, this will cause the basic concept of triangular material and the ability of the student's problem-solving ability not improve. That makes students confused about the triangle material when the teacher turns the question into a story problem.

Hawgent is a dynamic mathematical software from China [12]. Hawgent has a good form and very practical [13]. The software is designed according to the needs of the mathematical world, especially in geometry. Hawgent is a fast-growing software in China as media of mathematics learning that can help lecturers explain basic mathematical concepts to students [14]–[16]. It makes it easier for students to grasp the basic concept of mathematics, and it will be easier for them in problem-solving. In addition, some previous studies showed that Hawgent could improve students' mathematical ability in mathematics lessons [17], [18].

Based on the background presented above, this experiment was conducted to compare students' problem-solving skills with pre-test and post-test between the class that used Hawgent and the class that used the expository method to see the outcome of Hawgent and learning that does not use technology.

2. Method

The participants were 72 seventh-grade students from West Java, Indonesia, divided into two classes, control and experimental classes. The control class used the conventional teaching model, while the experimental class used Hawgent. This research will use the experimental method using pre-test and post-test to determine the difference in students' mathematical ability between the control and experimental class. Samples in the study were taken randomly to determine the experimental class and control classes. Problem-solving ability is designed according to the problem-solving indicator. The study's research data were analyzed using SPSS 25 to determine the differences between control classes and experimental classes [19], [20].

3. Result and Discussion

At the beginning of the study, the researchers gave problem-solving skills pre-test to the control and experimental classes to find out the difference in problem-solving skills of the two classes.

| Sample class       | Average | St.Dev |
|--------------------|---------|--------|
| Controlled Class   | 11.79   | 0.77   |
| Experimental Class | 11.36   | 0.89   |

Based on the studies, it was found that the average pre-test of the problem-solving ability of control class students was 11.79, and the experimental class average score was 11.36. It can be seen that the initial problem-solving ability of the control class was higher or 0.43 than that of the experiment class. The standard deviation of the conventional teaching class was 0.77, and the standard deviation of the experimental class was 0.89, which means the math problem-solving ability of the control class is more evenly distributed than that of the experiment class. At the next stage, testing will be conducted using SPSS to determine the difference in the initial problem-solving ability of elementary school students.
In the test results of the initial normality test of students' problem-solving abilities in Table 2, it can be seen that the control class and the experimental class both have a significance of 0.008 or less than 0.05, which means the data are distributed abnormally, and in the next step, we must use nonparametric tests to see the difference in the initial ability of the students' problem-solving ability.

The significance of the initial problem-solving ability of students is 1,000 or greater than 0.05. Since the significance is greater than 0.05, it can be interpreted that there is no difference in students' initial ability in the control class and experimental class. This means that, in the next stage, we can conduct treatment for the experimental class using Hawgent and for the control class using the expository method.

**Table 3. The test result of normality post-test data of problem-solving ability.**

| Class          | Kolmogorov-Smirnov Statistic | Shapiro-Wilk Statistic |
|----------------|-----------------------------|------------------------|
|                | Df  | Sig.  | Df  | Sig.  |
| Problem-solving ability | .158 | 36  | .023 | 36  | .025 |
| experiment     | .197 | 36  | .001 | 36  | .000 |

In Table 3, it can be seen the significance of students' problem-solving ability after receiving treatment. The significance in the control class is 0.023, and the significance in the experimental class is 0.001. Both the control class and the experimental class have a significance below 0.05. The data will then be processed using nonparametric tests to determine differences in abilities of the two classes.

**Table 4. The result of the nonparametric tests on problem-solving ability.**

|                | problem-solving ability |
|----------------|-------------------------|
| Mann-Whitney U | 366.000                 |
| Wilcoxon W     | 1032.000                |
| Z              | -3.194                  |
| Asymp. Sig. (2-tailed) | .001                  |

In the test results of the two average differences that can be seen in Table 4, the significance of the problem-solving skill of elementary school students is 0.001. Since this study intends to see the differences in the problem-solving ability of the experiment class, the significance should be divided by 2, which means 0.001/2 = 0.0005. As 0.0005 is smaller than 0.05, it indicates that the problem-solving capability of the experimental class is better than the problem-solving ability of the control class.

At the beginning of the study, the researchers asked students the formula of the circumference and area of a triangle. Many elementary school students were able to solve the question, but when the researchers asked students about the triangle and rectangular relationships, none of them answered the question. From here, the researchers can see that the teaching method that teachers usually used only explains formulas and then gave examples of questions to students. When the researchers asked about the relationship between triangles and rectangles, students felt confused because the basic concept of students was weak. Similarly, when the researchers gave a story question about triangles and rectangles...
to see students' problem-solving abilities, students found it difficult to understand, design, and answer questions from the researchers. After observing the students' initial abilities, the researchers explained the relationship between triangles and rectangles assisted by Hawgent that can be seen in Figure 1.

In Figure 1, it can be seen that by using Hawgent, the students can see that the proof of the triangle formula is 180 degrees. Students knew that the sum of square corners is 360 degrees. When a square is divided by two into a triangle, it can be known that the sum of corners of the triangle is 180 degrees.

![Figure 1. Proving a triangle is half a square using Hawgent.](image)

Afterward, when the researchers asked students why the total of angles in the triangle was \( \frac{\pi}{2} \). The researchers also found that no student could prove that the total of angles in the triangle was \( \frac{\pi}{2} \). Even though the concept that the researchers asked is a basic concept that students must master in triangle lessons, this question also can stimulate students' mathematical ability. As such, when the teacher changes the question to a more difficult level, students can do it easier than students merely memorize the triangle formula. After that, the researchers again proved the sum of angles in the triangle was 180 degrees using dynamic mathematic software shown in Figure 2. We can see the angle in the triangle, which is blue, evidenced by a straight line. It is proven that angles A, B, and C form a straight line of 180 degrees.

In this study, the researchers also saw that students were more active when teachers directed students to prove a basic triangle concept. Students also seem interested in Hawgent learning media. Thus, the researchers concluded that in addition to improving elementary school students' problem-solving ability, Hawgent could also increase students' confidence to answer questions from teachers and students' interest in learning. The results are similar to the findings of several previous studies that technology can improve students' mathematical abilities in many aspects [21]–[24].

At the last meeting, the researcher did not forget to ask some students' opinions as an evaluation material for Hawgent. The results of student responses on Hawgent learning media can be seen in Table 5.

| student | Statement |
|---------|-----------|
| S1      | I am delighted to learn mathematics using Hawgent learning media. |
| S2      | Hawgent can help me to master the basic concept of triangles. |
| S3      | Now I understand the concept of triangles. |
| S4      | I cannot wait to find out the proof of mathematical concepts in another sub-chapter. |
| S5      | I hope Hawgent can be used on all mathematical materials. |

Table 5. Student responses to Hawgent.
Figure 2. Proof of the sum of angles in the triangle using Hawgent.

4. Conclusion
Hawgent is proven to enhance students’ problem-solving skills in the indicators of analysis problems, devise a plan, carrying out the plan, and evaluation on the triangle. In addition, the researchers found that Hawgent can increase the attractiveness of students. Therefore, elementary school students are more enthusiastic and confident during teaching and learning activities. Based on the evaluation results, Hawgent also received positive feedback from students. Future research can be about the effect of Hawgent on students’ mathematical ability in university.

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