Increasing primary school students’ reasoning ability on the topic of plane geometry by using hawgent dynamic mathematics software

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Abstract. Plane geometry is one of the topics taught in middle school that is difficult to understand. Mostly, teachers use the traditional teaching method when explaining this concept which is why most students only memorize the formula for plane geometry without knowing how the formula is formed. These factors affect students’ reasoning ability. According to the information above, there are two main purposes of this research. The first purpose is to know how significant is the effect of Hawgent dynamic mathematics software on primary school students’ reasoning ability and the second purpose is to compare primary school students’ reasoning ability between the experimental and controlled classes. The sample of this research is 30 5th grade students in one of the primary schools in Cimahi city, Indonesia in the year of 2019/2020. The data collection will be done by using the pre-test and post-test to compare the primary school students’ reasoning ability in the experimental and controlled class. The data will be processed by using SPPS 16 and Microsoft excel. The result of this research is that there is an effect in students’ reasoning when using Hawgent dynamic mathematics software as a learning media and comparing the reasoning ability of the controlled and experimental class on the topic of plane geometry.

1. Introduction

Mathematics is a knowledge that is difficult to understand as it is abstract [1]. That is why the presentation of mathematics topics is often linked to everyday life so that students can find the concept and develop their mathematical ability based on the experience and knowledge they have. Students can solve a problem when they can learn one problem and able to use their knowledge to solve another problem [2]. This skill is often known as High Order Thinking Skills. High Order Thinking Skills are the ability to connect, manipulate, and change knowledge and experience that are critical and creative to solve a problem in a new situation and condition.

The development of computer technology and it’s software has influenced the teaching world now [3]. All subjects are required to use technology to support industry 4.0. Teaching media mastery is a requirement for all teachers. Learning media that is commonly used is the computer. The role of media is very important in the teaching process so that the topic is quickly conveyed to the students and are easily accepted by the students [4]. There are a lot of media that can use a learning media such as using Microsoft PowerPoint to increase students’ reasoning ability [5], using Microsoft Excel to increase students’ mathematical displacement and disposition ability [6], etc.
Reasoning ability is a cognitive process where students analyze in a systematic and specific way for the problem that they are facing, being able to differentiate the problem accurately and thoroughly and also able to identify and study the information to plan a strategy for solving the problem. According to Rohaeti [7], mathematical reasoning is a mathematical skill dan accuracy to combine early knowledge, mathematical reasoning ability, and cognitive strategy to solve a mathematical problem. A person who can think critically is someone that can conclude what they know, know how to use the information to solve a problem and able to search for relevant information source to support the problem solving [8]. Mathematical reasoning ability is a thinking ability that is known with the ability to identify the assumptions given, state the main problem, determine the consequences in taking the provision, detecting any bias based on a different point of view, give data/definitions/theorems in problem-solving [9-15].

According to the explanation above, mathematical reasoning ability is a basic ability to solve problems. To increase the reasoning ability, the use of interactive multimedia is needed as a learning media innovation now. There are also learning media that can be developed for abstract mathematic learning as this will increase the students’ mathematical reasoning ability by using hawgent dynamic mathematics software. Hawgent dynamic mathematics software is a mathematic learning media from Guangzhou, China that is developed to solve mathematical problems [16,17]. Hawgent has a simple appearance, can be easily operated but flexible and can picture out difficult mathematical concepts. Hawgent can help students to solve abstract mathematical problems and it can also increase the students’ mathematical ability [18-20]. Besides that, hawgent can also make learning mathematics more fun and enjoyable [21].

According to the information above, this research focuses on the use of Hawgent dynamic mathematics software as a learning media on the topic of plane geometry of primary school students’ reasoning ability. This research aims to develop technology-based learning media to increase primary school students’ reasoning ability before and after the plane geometry topic is thought.

2. Method
The method of this research is using the experimental method that aims to analyze the improvement of primary school students’ reasoning ability between using Hawgent dynamic mathematics software and traditional teaching method. There are 5 questions for the reasoning ability test and these questions are based on the indicator on mathematical reasoning standard as follows 1) checking the validity of argument, explanation, and method of problem-solving, 2) solving mathematical problems with a clear reason, 3) recognizing data linkage to a mathematical problem, 4) identify assumptions, 5) arranging answers to mathematical problems that come with arguments [10]. The sample of this research is taken from West Bandung district, Indonesia with a total of 32 students from 3rd grade. The research uses the pre-test and post-test design and the research design Figure 1.

![Research design](Figure1.png)

**Figure 1. Research design**

Information:
A : classroom random sampling
0 : Pre-test and posttest of mathematical reasoning ability.
X : students that learn plane geometry with hawgent dynamic mathematics software.

The students’ reasoning ability data will be taken from the pre-test and post-test results. The data from the two samples will then be processed by using Microsoft excel. The preliminary and final results will be processed by using SPSS 22 with the following steps; Testing the normality of sample data, Test the Homogeneity of Variance, Average Difference Test.

2
3. Result and Discussion

3.1. Result

3.1.1. Pre-test data analysis on the students’ mathematical reasoning ability
Before carrying out the teaching process on the topic of plane geometry using hawgent dynamic mathematics software, a pre-test was done to know the students’ initial reasoning ability of the two classes.

Table 1. Normality pre-test result

| Class   | Kolmogorov-Smirnov* | Shapiro-Wilk |
|---------|---------------------|--------------|
|         | Statistic df Sig.   | Statistic df Sig. |
| ability |                      |              |
| control | 0.141 30 0.131       | 0.949 30 0.160 |
| experiment | 0.223 30 0.001       | 0.886 30 0.004 |

According to Table 1, the significance value for the experimental is 0.131 and controlled classes are 0.001. The significance of controlled classes value is less than 0.05 which means that $H_0$ is rejected and the normality test is done. The pre-test sample was not evenly distributed and as a result, the Mann-Whitney test was carried out (Table 2).

Table 2. Average pre-test result on students’ mathematical reasoning ability

| mathematical reasoning ability | Mann-Whitney U | Wilcoxon W |
|--------------------------------|---------------|------------|
| Mann-Whitney U                 | 402.000       | 867.000    |
| Z                              | -0.720        |            |
| Asymp. Sig. (2-tailed)         | 0.472         |            |

According to Table 2, the t-test result of the students’ mathematical reasoning ability is 0.472 in which it is higher than 0.05 so $H_0$ is accepted. In conclusion, we can say that there is no difference in the students’ initial reasoning ability between the controlled and experimental classes. The experiment of the classes will be conducted under the same condition to be able to achieve comparable post-test results.

3.1.2. Post-test data analysis on the students’ mathematical reasoning ability
After the two classes receive the teaching process, a final test (post-test) was carried out. The post-test result will be used as the basis for the research hypothesis.

Table 3. Normality post-test result

| Class   | Kolmogorov-Smirnov* | Shapiro-Wilk |
|---------|---------------------|--------------|
|         | Statistic df Sig.   | Statistic df Sig. |
| ability |                      |              |
| control | 0.129 30 0.200       | 0.937 30 0.077 |
| experiment | 0.245 30 0.000       | 0.787 30 0.000 |

According to Table 3, the significant value for the controlled class is 0.200 while the significant value for the experimental class is 0.000. This means that the $H_0$ is rejected because the significance of the experimental class value is less than 0.05 and that is why the normality test is done. The post-test sample was not evenly distributed and as a result, the Mann-Whitney test was carried out (Table 4).
Table 4. Average pre-test result on students’ mathematical reasoning ability

|                   | Mann-Whitney U | Wilcoxon W | Z       | Asymp. Sig. (2-tailed) |
|-------------------|----------------|------------|---------|------------------------|
| mathematical ability | 297.000        | 760.000    | -2.280  | 0.023                  |

According to Table 4, the t-test result of the students’ mathematical reasoning ability is 0.023. This result is lower than 0.05 in which $H_0$ is rejected and $H_1$ is accepted. This means that the students’ mathematical reasoning ability learning achievement when using hawgent mathematic dynamic software is better than the traditional teaching method. After knowing that the experimental class is doing better than the controlled class, we are going to do again the test to see the difference in the improvement of students’ mathematical reasoning ability when using hawgent mathematic dynamic software and traditional teaching method.

3.1.3. Analysis on the difference in the improvement of students’ mathematical reasoning ability

Analysis of reasoning ability improvement which is influenced by hawgent mathematic dynamic software using data gain reasoning ability. Test results are presented in Table 5.

Table 5. Normality post-test result

| Class   | Kolmogorov-Smirnov\(^a\) Statistic | df | Sig. | Shapiro-Wilk Statistic | df | Sig. |
|---------|------------------------------------|----|------|------------------------|----|------|
| ability | control                            | 0.067 | 30 | 0.200                  | 0.982 | 30 | 0.869 |
|         | experiment                         | 0.190 | 30 | 0.007                  | 0.914 | 30 | 0.018 |

According to Table 5, the significant value for the controlled class is 0.200 while the significant value for the experimental class is 0.007. This means the experimental class data is not normal. Since there is one abnormal then proceed with the Mann-Whitney Test (Table 6).

Table 6. Average result on students’ mathematical reasoning ability

|                   | Mann-Whitney U | Wilcoxon W | Z       | Asymp. Sig. (2-tailed) |
|-------------------|----------------|------------|---------|------------------------|
| mathematical ability | 281.500        | 746.500    | -2.493  | 0.013                  |

According to Table 6, the result of the t-test on the students’ reasoning ability improvement is 0.013. This result is lower than 0.05 in which $H_0$ is rejected and $H_1$ is accepted. This means that the students’ mathematical reasoning ability improves more when hawgent mathematic dynamic software is used in the teaching method compared to the traditional teaching method.

3.2. Discussion

Before making the learning media using hawgent dynamic mathematics software, researchers collected data on the topic of plane geometry in primary schools and analyze the problems that are faced by students. The research result from 30 fifth grade primary students that have been given 5 reasoning questions on the topic of geometry is shown in Table 7.
Table 7. Achievement on Reasoning Ability on Plane Geometry

| Question                                         | Able | Not able |
|--------------------------------------------------|------|----------|
| Able to explain the similarity of 2 plane geometries | 10   | 20       |
| Able to explain the correlation of 2 plane geometries | 12   | 18       |
| Able to explain formula of plane geometry        | 8    | 22       |
| Able to relate the plane geometry concept to everyday life | 14   | 16       |
| Able to solve plane geometry problems            | 19   | 11       |

On Table 7, even though most students can solve plane geometry problems using the formula, but we can see that students have difficulties or are unable to critically think as only 26.67% of the students can explain the formula of plane geometry, only 33.33% of the students can explain the similarity of 2 plane geometries, only 40% of the students can explain the correlation of 2 plane geometries and only 46.67% can relate the plane geometry concept to everyday life.

Figures 2 and Figure 3 shows that the students do not fully understand the basic concept of plane geometry. Students’ difficulties on the indicator of checking the validity of argument, explanation, and method of problem-solving that can be seen in Figure 2 as students can only guess that rhombus is bigger than square.

Figure 2. Students are unable to fully understand the basic concept of plane geometry

On the indicator of solving mathematical problems with a clear reason that can be seen in Figure 3, even though teachers have given an explanation about 2 plane geometries, students still answered wrongly with a clear explanation.

Figure 3. Students do not know the correlation between parallelogram and rhombus.

We can conclude that throughout the teaching process of plane geometry, students have difficulties in, understanding the basic concept of various four-sided figures, analyzing in a systematic and specific
about plane geometry problems, differentiate the problem carefully and meticulously and also identifying and studying the information given about sides on plane geometry to plan up a strategy for solving the problem. With these problems that the students’ are facing, hawgent dynamic mathematics software can help and guide the students to improve their reasoning ability.

According to Figure 4, With the help of hawgent dynamic mathematics software, students’ are guided to find out the basic concept of plane geometry and how to find the formula for rhombus and parallelogram. This way, not only that students can use the formula of plane geometry, but they can also improve their reasoning ability both when they are solving mathematical problems or in their everyday life. Based on the results of the study [11] that the hawgent triangle dynamic mathematical software can be applied to seventh-grade students, this can be seen from the success of students in learning mathematics by using the hawgent triangle dynamic mathematical software increased. Dynamic mathematics software as a learning medium is received positively by students.

At the end of the teaching time, researchers interviewed 3 out of 30 students that have different abilities to evaluate and give their opinion on the Hawgent dynamic mathematics software as a learning media on the topic of plane geometry (Table 8).

| Students’ abilities | Respond | Suggestion |
|--------------------|---------|------------|
| High               | 1. Very helpful in explaining plane geometry.  
                    2. Mathematics becomes more enjoyable and interesting.  
                    3. Wants to try different shapes of plane geometry using Hawgent dynamic mathematics software. | 1. Hopes that the teacher will teach the students on how to make them. |
| Moderate           | 1. I believe the learning media can help to improve my grades because I can understand the concept better.  
                    2. I would be happy if mathematics is taught using a software rather than writing on the board.  
                    3. All this time I will always memorize the formula but now I know how it is formed.  
                    4. It encourages me to ask and try mathematics problems in class. | 1. The colors and picture need to be improved.  
                2. If a sound effect can be added it would be more interesting. |
Students’ abilities | Respond | Suggestion
--- | --- | ---
Low | 1. It is interesting and makes me understand mathematics better.
2. Very happy and hope that other mathematics concepts can be explained using Hawgent dynamic mathematics software. | 1. Hopefully, other mathematics concepts can be explained using the software. |

4. Conclusion
According to the research, we can see that in general, using a technology-based learning media can improve the learning outcome better than the traditional teaching method; the primary school students’ reasoning ability is better when using hawgent dynamic mathematics software compared to the traditional teaching method.

5. Acknowledgments
The author would like to thank all those who have motivated and supported those who cannot be mentioned one by one who has been very helpful in completing this paper. And do not forget to thank the authors to all the organizers of the International Seminar on Applied Mathematics and Mathematics Education 2020 Siliwangi Institute of Teacher Training and Education. Finally, I hope this article will benefit all readers and writers in particular.

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