Design and Implementation of GeoGebra Learning Activities of Area and Perimeter of Rectangles for Primary School Students

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Abstract. GeoGebra-based mathematics learning is an approach to teach mathematics that can support students to think mathematically. Learning using GeoGebra provides students with a new hands-on experience in learning mathematics as they can understand the mathematical concepts both from visualisation and representation. This study exploits the method by designing GeoGebra-based mathematics learning on the area and perimeter of rectangles. This study aims to provide a varied and exciting learning experience, support students in thinking mathematically and give a chance to students to solve mathematical problems correctly and fluently. The design of learning activities for the area and perimeter of rectangles with GeoGebra was tested with 4 elementary school students. The results indicate that students begin to understand the area and perimeter of a rectangle logically, although some are still doubts when answering the questions given.

1. Introduction
Mathematics education is a field of science that discusses how to think mathematically in life. Mathematics learning in schools focuses on students' ability to think mathematically. Mathematical abilities that students have acquired derived from contributions of mathematics learning activities [1]. Mathematical thinking ability is the paramount ability in mathematics calculations and lessons, in which mathematical thinking skills need to be possessed and embedded from the start so that students can think and make decisions independently [2]. The ability of students to think mathematically become apparent, particularly in problem-solving tasks. However, using conventional methods, mathematics instruction seems ineffective to develop students' mathematical thinking skills [3]. Some studies have shown that many students were unable to solve mathematical problems related to the real world [1], creative thinking [4], and logical thinking [5], and students did not have problem-solving skills and lacked confidence in solving problems. These phenomena indicate that students' mathematical thinking ability is still low and is still far from the essence of teaching mathematics education.

Technology-based mathematics learning has enabled to support students' mathematical thinking skills, especially elementary school students. Through digital technology, students can see the visualisation and representation of abstract mathematical concepts. For example, students can see the representation of 2-D shapes through a mathematical application such as GeoGebra. Klemmer and
Rapoport [6] found that origami and GeoGebra activities contribute to second graders' geometric thinking. Putra et al. [7] also found that dynamic number card games could stimulate first graders' number sense. These findings show that technology-based mathematics learning is an approach that can support elementary school students' mathematical thinking, especially during this COVID-19 pandemic.

We are interested in GeoGebra because it is a relatively breakthrough in the teaching of mathematics in Indonesia. It is one of the interactive media that can be accessed online on its website and is used to teach mathematics and foster mathematical thinking skills to students. The present study aims to design a mathematical learning activity based on GeoGebra and tries it with primary school students. This study is critical because it seeks to explore the use of GeoGebra media in learning mathematics, especially in geometry material, and determine the effectiveness of GeoGebra in training students' mathematical thinking skills. As stated by Mahmudi [8], GeoGebra can be used as a medium in learning mathematics, especially in geometry material, to visualise or demonstrate the concept of geometry and as a tool for constructing geometric concepts. The expected benefit of implementing this project is to make it easier for teachers to achieve the objectives of teaching mathematics education, especially in teaching geometry concepts to students.

Meanwhile, students participating in learning using GeoGebra-based media play a significant role in building their mathematical thinking skills and solving problems based on logical thinking, not just relying on rote memorisation. A further benefit is an education in Indonesia. GeoGebra can serve as a medium that can support mathematics learning broadly to all levels of education and, of course, adequate facilities to facilitate the implementation of the mathematics learning process.

2. Methods

This study used design research for designing learning instruction on the area and perimeter of rectangles [9]. We use the approach of design research from a learning design perspective [10]. There are three phases of conducting a design experiment: preparing, experimenting in the classroom and conducting retrospective analysis. Due to the Covid-19 pandemic, the experimenting in the classroom has changed into experimenting with one-to-one students from primary schools in Indonesia.

In the preparing phase, the researchers began to study the mathematics contents that appeared in the Indonesian curriculum. Due to broad mathematics contents, the team chose a topic about the area and perimeter of rectangles. We chose this topic because it is fundamental for students to understand more advanced mathematical concepts about the area and perimeter of 2-D shapes. Then, we began to create the tasks on GeoGebra. The tasks aim to support students in understanding the area and perimeter of rectangles through activities using GeoGebra. The tasks were firstly created by the second author using GeoGebra based on some previous GeoGebra activities [11]–[14], and it can be reached at https://www.geogebra.org/m/t3dkgfgp under the title “luas dan keliling persegipanjang” (area and perimeter of a rectangle).

Figure 1 presents the task of finding the meaning of the rectangle area, and figure 2 presents the perimeter of a rectangle. To find the area and perimeter of rectangles, students can drag each point (A, B, C, and D) and observe the activity. Meanwhile, we added additional questions under the activity (Figure 3). The question is to let students explain how to find the area and perimeter of rectangles.
In the second phase, the tasks were tested with 4 primary school students (2 boys and 2 girls) from different schools in Riau, Indonesia. All participants sat in the fourth grade who had studied the area and perimeter of rectangles, but they did not have any experiences learning mathematics using GeoGebra. Therefore, this activity provides challenges and opportunities for the students to understand finding the area and perimeter of rectangles.

The task is assigned to students at the beginning of the learning activity. They have 20 minutes to complete the task and answer the questions. After that, the researcher and students discussed it for 10 minutes to reflect on their tasks.
First, we gave questions to each student after completing the activity. Then, we categorised their responses to the given questions. The students' answers were analysed qualitatively. To support the data, we analysed the data from the discussions during the lesson, and we recorded the discussion activities through screen recordings as evidence of the activities.

3. Results
From the research conducted, there are several results obtained. When trying out GeoGebra learning to four elementary school students, each student's response was not the same. When trying some activities on GeoGebra, student 1 showed a rigid learning attitude and did not understand the questions. When the researcher asked, "from the GeoGebra activity, how do you determine the area and perimeter of a rectangle that you understand?" Student 1 answered, "the area [is] length times width (with a re-explanation from the researcher) length plus width plus length plus width for circumference". Then the researcher asked, "what did you get from this GeoGebra activity?", He did not answer but showed an attitude of hesitation and seemed less understanding.

Student 2 showed an attitude that was not as rigid as the previous student, only that they needed some explanation in implementing the activity on GeoGebra. When asked how to determine the perimeter and area of a rectangle based on the previously experienced GeoGebra activity, he answered, "the area [is] length times width, we usually use \( L = p \times l \)" the researcher also asked, "what about the circumference? what do you get from GeoGebra activity?" The student answers, "for example, A, B, C, D returns to the beginning, a+b+c+d (there is a direction from the researcher when students answer), a to b, b to c, c to d, and d to a".

Meanwhile, when tested with student 3, he looked scared during the test. The researcher asked, "How to determine the area and perimeter of a rectangle?" The student answered, "length times width (with repetition of activities directed by the researcher) area is length times the width and perimeter are \( p+l+p+l \)".

Slightly different results were obtained from the 4th student. When the researcher directed the use of GeoGebra accompanied by an explanation of the material, students understood that their understanding must always be assisted. When working on the questions given by the researcher, students still have to be guided to stay focused on understanding the perimeter and area of a rectangle. When the researcher asked "How to find the perimeter of a rectangle", he answered "by dividing" then the researcher provoked the students' thoughts again to direct them to the correct answer "If divided, how do you divide it?" then the student answered, "multiplied". Then the researcher asked again, "multiplied? other than that, what else?", He again answered, "plus". The excerpts of the conversation demonstrate that students do not understand the concepts given because students guess the answers. The researcher asked him again, "If you add what is added?", the student answered by pointing at the width + width + length + length. Next, the researcher asked the students about the area of a rectangle, "How do you find the area of a rectangle?" then he answered, "The area is searched here (pointing to the inside of the rectangle)", then the researcher again provoked the students' thoughts "What is the inside of it", when asked again the student looked hesitant in answering, so the researcher had to direct the answer.

From the findings of the four students, there are interesting things; namely, the students can visualise rectangular shapes with different sizes. After running the rectangle applet in GeoGebra, students can understand the shape of a rectangle when asked what objects include rectangles around them. In addition, it shows that three out of four students began to understand the origin of the formula for the perimeter and area of a rectangle after running the GeoGebra applet.

4. Discussion and conclusion
These findings are supported by a study conducted by Nopiyanti [15] that GeoGebra-based learning media can increase student involvement in the learning process either with teachers or with other students. Based on the results obtained, it proves that learning mathematics using GeoGebra can
increase the involvement of students in understanding the concept of the area and perimeter of rectangles. In addition, this is also evident that students are not very good at running GeoGebra and therefore must be guided in its implementation. Likewise, during understanding mathematical concepts, students must always be guided to understand the mathematical concepts they have learnt.

The results also show that the use of GeoGebra in learning mathematics can support students' ability to visualise the mathematical concepts being taught; this is in line with previous research, namely, learning mathematics using GeoGebra can offer visualisation and opportunities to learn mathematics through practice and experiments that are more interesting. Allows students to learn logically rather than memorising formulas, as has been done in mathematics learning that has been applied so far[16].

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