

Development of Didactical Design Concepts of Areas of Squares and Rectangles Assisted by Geogebra in Middle School

Rostina¹, Sugiatno², Nurfadilah Siregar³

¹ Universitas Tanjungpura, Pontianak, Indonesia; rostina.fu201002@gmail.com

² Universitas Tanjungpura, Pontianak, Indonesia; sugiatno@fkip.untan.ac.id

³ Universitas Tanjungpura, Pontianak, Indonesia; nurfadilah.siregar@fkip.untan.ac.id

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ABSTRACT

Comprehension of overarching principles in texts for elementary and junior high school is deficient. The objective of this study is to create an instructional plan for understanding the notion of square and rectangular regions using GeoGebra as a tool. This study employs a didactical design research methodology with a descriptive qualitative approach. The didactic design discussed in this study pertains to the acquisition of knowledge regarding square and rectangular regions in junior high school. The study was carried out in a public junior high school located in Sungai Raya Kubu Raya. The data sources consist of primary and secondary data. Primary data is collected firsthand from sources in the field, directly from the research subject. The data is derived from test results and observations of eighth-grade students and mathematics teachers, which serve as the foundation for the development of didactical design. The secondary data consists of a literature review, which is derived from relevant literature sources that provide support or relevance to this publication, such as earlier research. The findings revealed that students had difficulties mostly in identifying flat shapes, calculating the area of squares and rectangles, understanding the correlation between square and rectangular areas, and utilising the notion of square and rectangular areas to solve problems. This learning impediment is surmounted by implementing a didactic design. The resulting didactic design incorporates the utilisation of GeoGebra software to address and overcome students' learning hurdles in the context of square and rectangular materials, with a focus on problem-solving.

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Corresponding Author:

Rostina

Universitas Tanjungpura, Pontianak, Indonesia; rostina.fu201002@gmail.com

1. INTRODUCTION

Mathematics is a field of study that employs logical reasoning to define and explain the relationships between quantities, structures, concepts, and forms. The field of mathematics is comprised of three primary components: algebra, analysis, and geometry. Some individuals categorise it into four primary elements, namely encompassing arithmetic, number theory, and statistics, as documented on the Indonesian language Wikipedia and in the UPI file directory labelled "The Nature of Mathematics."

Mathematics is an abstract discipline characterised by its numerous notations and symbols, which need mental comprehension. This is a primary factor contributing to the lack of enthusiasm among students towards mathematics, despite the necessity of teaching mathematics at all educational levels. The lack of comprehension of fundamental concepts and over-reliance on formula memorization among students is the underlying reason for their aversion towards mathematics (Sagisolo, 2020).

The continuous development of technology requires teachers and students to have a reciprocal relationship so as to bring creativity to learning. This is in line with the increasing importance of the use of technology by teachers and students in special schools, teaching with technology for success, and technology is also used in higher education (Baglama et al., 2017; Efe, & Baysal, 2017; Englund et al., 2017; Martin et al., 2020). The importance of Technology in learning and teaching mathematics is also stated in the National Council of Teacher Mathematics (NCTM, 2020).

In order to enhance student motivation in the context of mathematics education, the provision of props or facilities is deemed necessary. The utilization of technology serves the objective of enhancing student engagement by making instructional guidance more stimulating, hence fostering motivation. The clarity of guidance is enhanced, leading to improved comprehension. Teaching strategies exhibit greater diversity, facilitating a broader range of learning experiences. Students actively engage in increased guidance for their own learning. The range of technological tools utilized in the field of mathematics education is extensive. For instance, many tools such as mathematical assistance, measurement instruments, overhead projectors (OHP), and computer/laptop apps can be utilized. In contrast, Lestari (2018) suggests that the field of education can effectively employ computer technology for administrative purposes and data management, encompassing the organization and analysis of school-related information, as well as data pertaining to teachers and students. Furthermore, educators have the ability to incorporate technology into the process of curating educational resources and designing instructional materials for pupils. Equally significant to technology is the ease with which pupils can get diverse information from several sources when the internet is accessible.

In the process of teaching mathematics, computers can be used as a calculation tool when studying trigonometry, logarithms, comparisons, and others. Computers can also be used as a tool for presenting subject matter when it requires images, motion (animation), color or text. So all existing facilities can be used in visualizing concepts that students consider abstract in mathematics so contextual. Some software that can be utilized in math materials, namely: GeoGebra, Maple, Microsoft Mathematics, Cabri 3D, and others.

The dynamic geometry software called GeoGebra is an example of one of the biggest technological advances in software used in classrooms today. GeoGebra was created in 2001/2002 by Markus Hohenwarter. GeoGebra is a dynamic math lesson software, helping teachers to structure lessons, and predictions in geometry, algebra, and calculus. GeoGebra is a dynamic learning environment, that guides the user in creating mathematical objects and interacting with them. GeoGebra users, the majority of teachers and students, GeoGebra can be used to explain, explore, and model mathematical concepts and interactions between them, or in terms of mathematics in general (Delaviz & Leong, 2013).

GeoGebra allows learners to gain a stronger connection between geometry and algebra and to visualize abstract mathematical ideas, covering all school cycles and throughout university studies. Research by Hamzeh (2020) states that GeoGebra software has a positive impact on math classrooms. Various studies discuss the effects of GeoGebra software on increasing students' mathematics achievement levels (Lumbantobing, 2020; Simbolon, & Siahaan, 2020). GeoGebra can also encourage students in terms of exploration (Kovács et al., 2018).

Today, it is inevitable that science and technology form a major review in terms of growing every aspect of human life, such as how they can realize high acceleration when preparing a more supportive learning environment for students. Both science and technology are believed to create great opportunities for students to make in-depth observations of their understanding of specific concepts. Some of the technology-based learning tools commonly used in university-level mathematics learning include Maple, Matlab, GeoGebra, SPSS, and Fluent. The need for practical software that will be able to help them do

better understanding is still a major concern for educators. One of the right models that can foster students' level of understanding is by utilizing dynamic software in 40 languages such as GeoGebra (Safrida et al., 2018).

The subject matter within the expansive domain of mathematics necessitates the utilization of tools as a primary component of its instructional content, hence emphasizing the importance of using such tools during the learning process. GeoGebra, a computer-based application, offers the capability to visually represent two-dimensional fields. This feature has the potential to enhance students' learning experience by providing clear and engaging pictures, facilitating comprehension, and fostering individual enjoyment. The term "GeoGebra" is derived from the combination of the words "geometry" and "algebra." This software tool provides users with a range of features related to both geometry and algebra. It enables the visualization of geometric shapes and allows for the exploration of various area formulas. In addition to the aforementioned, it is worth noting that GeoGebra can be utilized for the creation of educational resources.

The material being studied in this research is specifically square and rectangular. In this study, researchers developed learning about the concept of flat area with the help of software in the form of GeoGebra which is very practical and has the effect and potential to lead to good things. The development of the didactical design of the concept of area is considered necessary because the understanding of the concept of area in elementary and junior high school textbooks is still lacking. This can be seen in the Junior High School Mathematics Book Class VII Semester II and the Happy Learning Mathematics Book Elementary / MI Class IV Student Book. The following are examples of problems and their solutions in grade IV math books. In the example problem at the beginning of the square and rectangle material lesson, students are presented with an example problem with the command "Determine the area of a square with side lengths as shown in the picture. The picture is a square with a side of 11cm. Then the solution appears in the form of $S = 11 \text{ cm}$, $L = s \times s$, $L = 11 \times 11$, $L = 121$. So, the area of the square is 121 cm^2 (Hobri et al., 2018).

The formulation of the problem in this study is "How is the didactical design of the concept of square and rectangular area assisted by GeoGebra?". The purpose of the research is to produce a didactical design of the concept of square and rectangular areas with the help of GeoGebra. This research is expected to be used as a reference for students who will conduct a study of the development of the didactic design of the concept of area assisted by GeoGebra for junior high school students. It can also increase the treasure of knowledge, especially in the field of mathematics in particular and education in general, and teachers are expected to be more skillful in designing teaching materials related to didactic design, so that it can be used as a consideration in teaching.

2. METHODS

This type of research is didactical design research with a descriptive qualitative approach. The didactical design referred to in this study is related to learning the concept of square and rectangle areas in junior high school. There are three stages in didactical design activities, namely didactical situation analysis before learning, metapedidactic analysis, and retrospective analysis (Suryadi, 2011). In this study, the researcher only did up to the stage of designing a didactical design without further implementation. So the design that has been made is used as a supplement to teaching materials for teachers on square and rectangle materials. The research steps are the preparation stage, the implementation stage, and the final stage.

In this preparation stage, the didactical situation before starting learning. In this initial stage, the form of didactical design is still a hypothesis, so it is necessary to carry out activities that support this initial stage, in the form of the selection of a mathematical concept, which will later become the material in the study. In this study, the material is square and rectangular; After the material is determined, an instrument can be made in accordance with the material to identify students' learning obstacles;

Furthermore, the instrument that has been prepared is continued by conducting tests for students. The test given is an objective test.

In the implementation stage, several activities are carried out, namely: Carrying out tests in accordance with the questions that have been prepared in the initial stage; The test results that have been answered by students are sorted based on their correctness; From the test results, students are then asked to make a description answer according to the answer they chose on the multiple choice question. Students are asked for their description answers to explore students' learning obstacles on square and rectangle material. The learning obstacles explored here are only epistemological obstacles in accordance with the limitations of learning obstacles that exist in the limitations of this study. At this stage of the implementation, students' learning obstacles were found in solving the given problems. The learning obstacles are in the form of recognizing flat shapes, determining the area of square and rectangle, the relationship between square and rectangle area, and applying the concept of square and rectangle area to solve daily life problems. The data collected in the form of information about the situation and conditions, facts, and problems that exist in mathematics learning in the field which ultimately requires the development of didactic design of the concept of square and rectangular area assisted by GeoGebra in junior high school. Then, a literature review was conducted so that the necessary literature could be collected and the didactic design of the concept of area assisted by GeoGebra could be supported. This literature review is obtained from various sources, including books, reputable journal articles, guides, and the internet, all relevant to and supporting the research. The didactical design was prepared based on the existing learning obstacles.

In the final stage, the conclusion from the results of the initial study to the didactic design will answer the problem of this research. The development of this research only reaches the stage of forming a didactical design, which is in the form of a didactical design with GeoGebra-assisted square and rectangle teaching materials.

This research was conducted at SMP Negeri 1 Sungai Raya Kubu Raya. This paper sources its data from primary and secondary data. Primary data is obtained directly from sources in the field, which is obtained from the research subject. The data is based on data obtained from test results and observations of VIII grade students and mathematics teachers as material in the preparation of didactical design. The secondary data is in the form of a literature study, which is obtained from literature that can support or relate to this paper, for example from previous research. The usefulness of this data is assisted in analyzing the first data, namely primary data obtained directly from the field. This research instrument is taken from As'ari et al. (2013) and Hobri et al. (2018) which totaled 10 questions with each indicator as follows:

1. Recognition of flat shapes in the form of regular facets.
2. Determining the area of squares and rectangles.
3. The relationship between the area of a square and a rectangle.
4. Apply the concept of the area of squares and rectangles to solve daily life problems.

3. FINDINGS AND DISCUSSION

The learning scenario regarding the relationship between the area of a square and a rectangle is carried out using test questions given to students to find out the learning obstacles which are then used as a reference for making didactical designs which include the introduction of flat shapes, determining the area of a square and a rectangle, the relationship between the area of a square and a rectangle and applying the concept of square and rectangular area to solve daily life problems.

Students were given problems about the introduction of flat shapes, determining the area of square and rectangular areas, the relationship between square and rectangular areas and applying the concept of square and rectangular areas to solve daily life problems. From the 10 problems given, the following results were obtained:

Table 1. Frequency of Number of Students Answering Correctly and Incorrectly

Question	Number of Students Correct Answer	Number of Students Answered Wrong	Error Presentation (%)
1.	29	1	3,33
2.	18	12	40
3	18	12	40
4.	21	9	30
5.	23	7	23,33
6.	15	15	50
7	7	23	76,67
8.	9	21	70
9.	14	16	53,33
10.	17	13	43,33

Table 2. Frequency based on learning obstacle for each question

Learning Obstacle	Question	Total	Percentage (%)	
Introduction to flat shapes	1	1	3,33	
	Determination of area of square and rectangle	2	12	40
		3	12	40
		5	7	23,33
		6	15	50
Area relationship between square and rectangle	4	9	30	
	7	23	76,67	
	8	21	70	
	9	26	53,33	
Application of the concept of square and rectangular area	10	13	43,33	

Table 3. Frequency by learning obstacle

Learning Obstacle	Total	Percentage (%)
Introduction to flat shapes	1	3,33
Determination of area of square and rectangle	46	38,33
Area relationship between square and rectangle	69	57,5
Application of the concept of square and rectangular area	13	43,33

From the research results that have been presented, students' learning obstacles in question No. 1 only occurred to 1 student. The student initially answered incorrectly, but after the researcher reconfirmed his answer, the student changed his answer choice to c, which is a pentagon. This student's answer can indicate that the student does not remember the type of square flat building. To overcome these students, the types of flat shapes can be explained, starting with regular facets. To make it easier and more accurate in size and shape, images are presented to students with the help of Geogebra. The shapes presented to students are as follows:

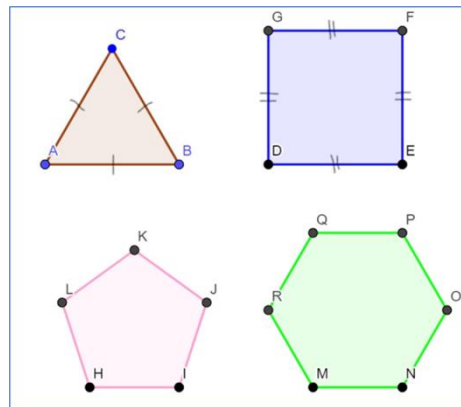


Figure 1. Various Kinds of Flat Shapes

All the figures in Figure 2 are called regular facets because they have equal sides and equal angles for each facet. When the angles and side lengths are shown, they are clearly visible in Figure 3 below:

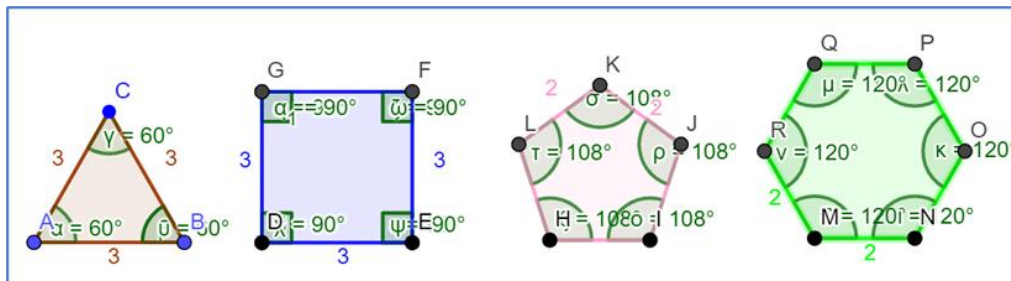


Figure 2. Regular Square n with Side and Angle Lengths

Explaining to students starting with the image of the triangle in Figure 1, then continuing the image of the triangle is detailed to be more specific. By explaining the existence of various triangles and their examples. Every triangle that exists is regular and irregular, for triangles there are also many names according to the angles and sides. Figure 3 and Figure 4 are the names of the triangles as follows:

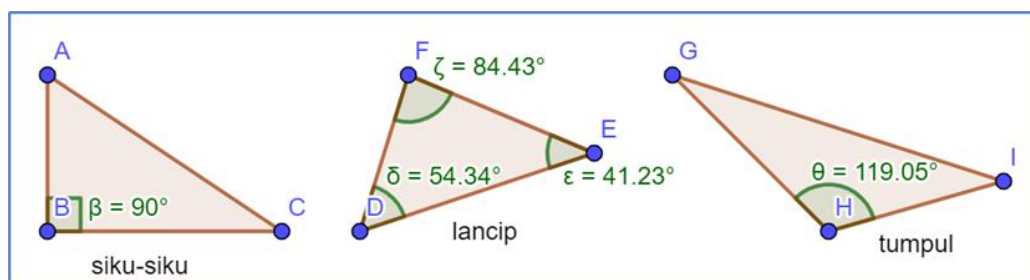


Figure 3. Triangles by Angle Magnitude

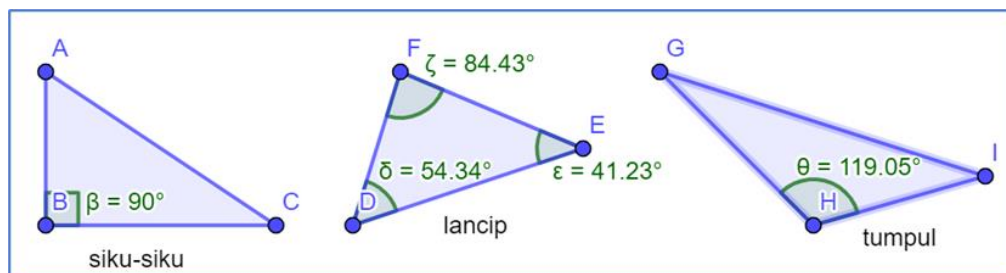


Figure 4. Triangles by Side Length

After triangular flat shapes, continue with rectangular flat shapes. Similar to triangles, rectangles each also have a name. For details can be seen in Figure 5 below:

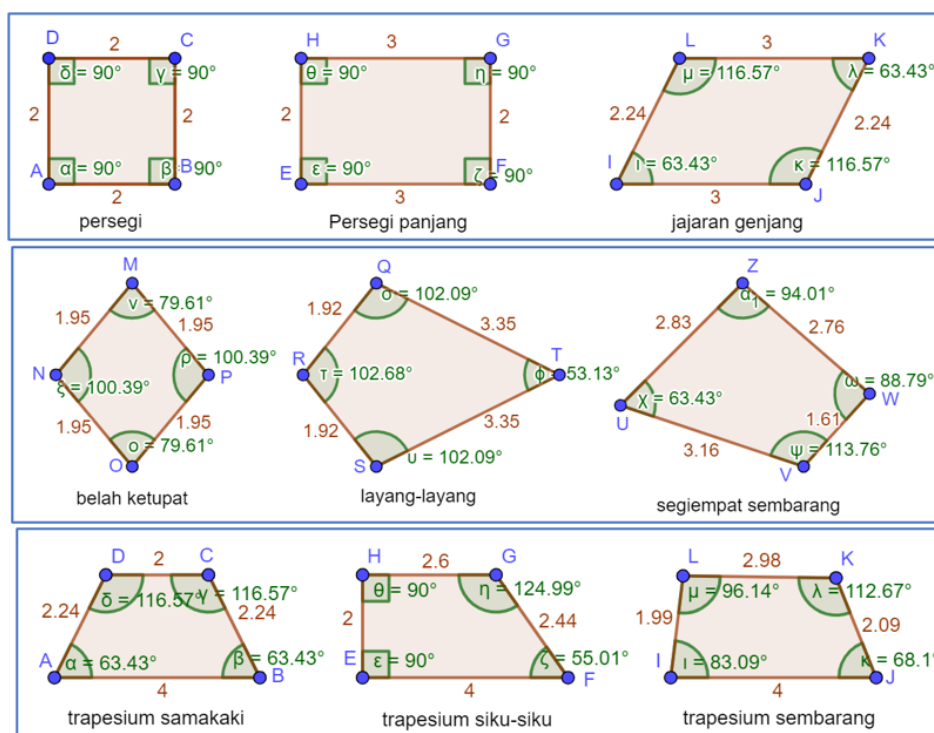


Figure 5. Types of quadrilaterals

This is in accordance with the research of Tamam & Dasari (2020) who said Geogebra is a computer program to support the teaching and learning process of mathematics subjects, especially geometry, algebra, and statistics. The various facilities provided by Geogebra software can certainly be a good medium to help users visualize abstract geometric objects quickly, accurately, and efficiently. In addition, it was found that there were several significant results obtained. These findings, including Geogebra, make it easier for students to understand geometry. Students also tend to have more fun learning geometry by using Geogebra, which is operated by using a computer.

For problems No. 2 and 3, students are asked to determine the area of a square and a rectangle. However, in reality, errors still occur as much as 40% in both questions. Learning obstacles in determining the area of a square and rectangle need to be overcome, through teaching the right concepts and explanations, so that in the future it does not interfere with the continuation of other materials. Understanding the concept of square and rectangle areas is important because the material is a prerequisite material for building material with dimension 3. Therefore, if the learning obstacle in dimension 2 is not addressed, the existing errors will be sustainable. Problem Nos. 2 and 3 were also explained using Geogebra. The solutions for problems No. 2 and 3 are in Figure 7 and Figure 8 respectively:

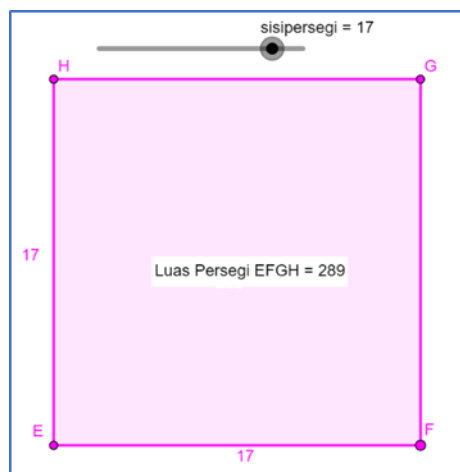


Figure 6. Square area EFGH

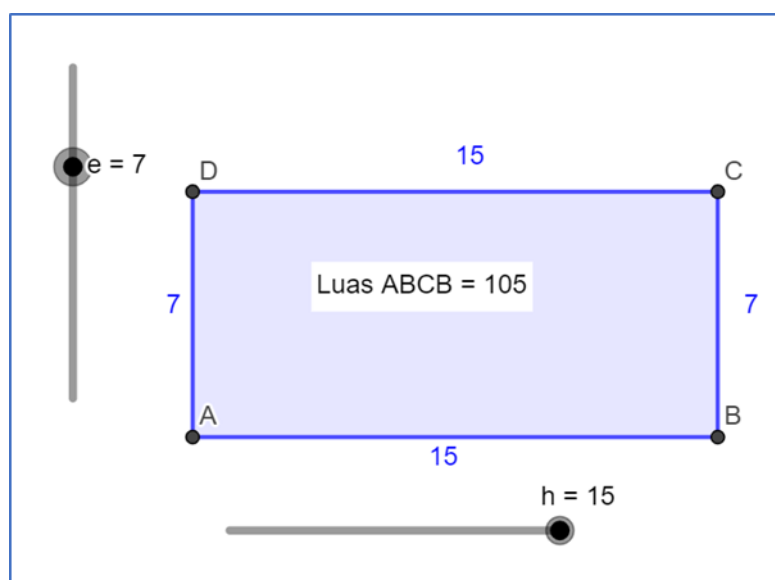


Figure 7. Rectangle Area ABCD

This is in accordance with the results of research by Zulnaldi & Zamri, (2017) whose aim was to identify the effect of GeoGebra software on students' conceptual and procedural knowledge and students' mathematics learning achievement. The findings show that students who use GeoGebra to learn mathematics have higher conceptual and procedural knowledge of mathematics when compared to those who learn mathematics through conventional methods.

For problem No. 4, students have been brought to the relationship between the area of a square and a rectangle. However, it was expressed in the form of a picture. In this question, No. 4, only 30% got the answer wrong, and the remaining 70% got it right. So the learning obstacle in question No. 4 still exists even though most students can answer correctly. It can be indicated that many students answered correctly because of the picture, so the learning obstacle assisted with GeoGebra produces more benefits for students. For problem No. 4, it can be drawn in the same place as in Figure 9. If it is drawn in a separate place still on one screen, then the image is as in Figure 10. If problem No. 4 wants to be calculated, it can be directly calculated on the GeoGebra screen as well. Information about the calculation can be displayed on the same screen. Take a look at Figures 9 and 10 below:

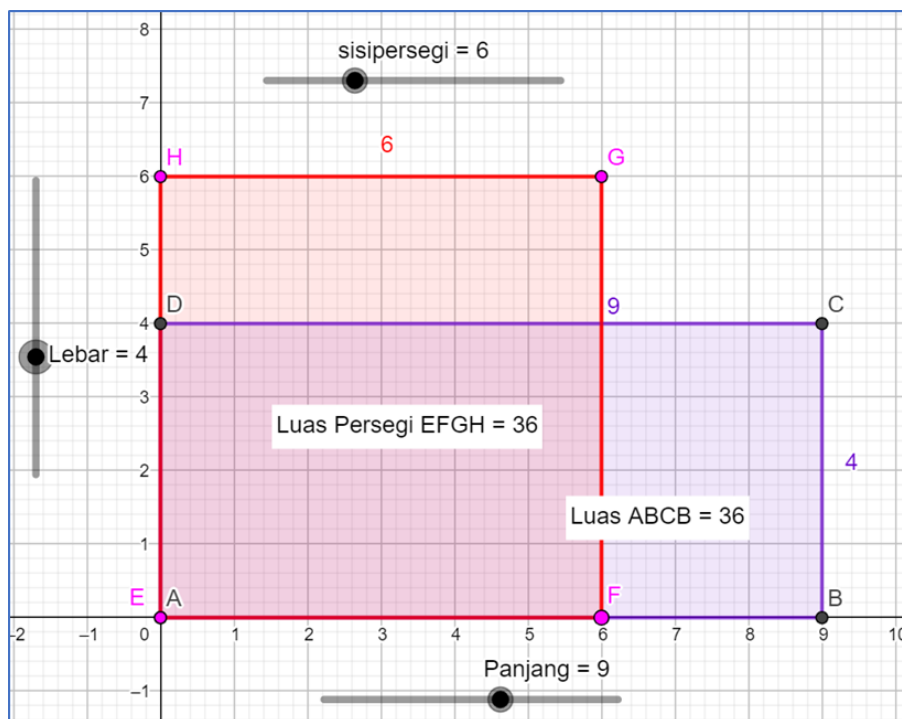


Figure 8. Square and Rectangle Areas Are Equal

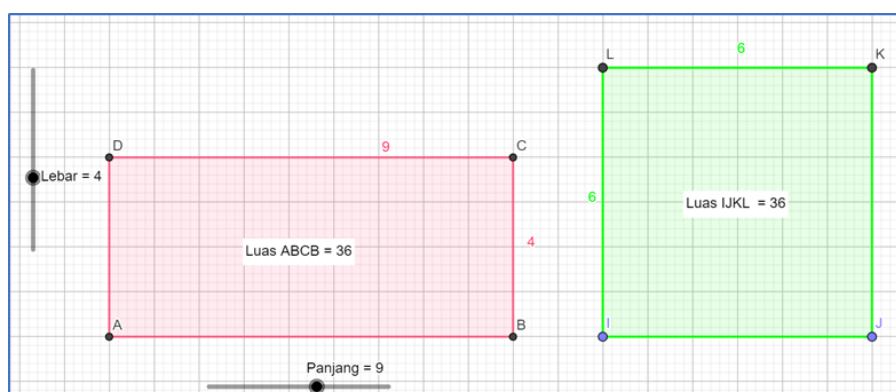


Figure 9. Square and Rectangle Stand Alone

4. CONCLUSION

In general, it was found that students' learning obstacles were in the form of errors in recognizing flat shapes, determining the area of square and rectangle, the relationship between square and rectangle area and applying the concept of square and rectangle area to solve problems. This learning obstacle was overcome by creating a didactical design. The resulting didactical design contains problem-solving with the help of GeoGebra software to minimize, reduce, and overcome students' learning obstacles in square and rectangle materials.

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