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*Research articles*

# Developing instructional props to reinvent the area of parallelogram and triangle in online learning

**Ketut Sarjana[1], Ni Made Intan Kertiyani[1], Laila Hayati[1], Baidowi[1]**

**Abstrak** Konsep luas pada materi geometri matematika di sekolah dasar merupakan hal yang abstrak untuk peserta didik yang masih dalam tahap berpikir konkrit. Untuk menjembatani perbedaan tahap berpikir diperlukan alat bantu belajar seperti alat peraga dalam pembelajaran. Namun, alat peraga kebanyakan digunakan pada pembelajaran tatap muka, sementara pandemi menyebabkan pembelajaran harus dilakukan secara daring dari rumah. Penelitian ini mengembangkan alat peraga dan petunjuk penggunaannya untuk membantu peserta didik menentukan luas jajar genjang dan segitiga dalam pembelajaran daring. Penelitian ini menggunakan model ADDIE (*Analysis*, *Design*, *Development*, *Implementation*, *Evaluation*). Instrumen pengumpulan data terdiri dari lembar observasi, pedoman wawancara, lembar validasi dan tes pemahaman luas jajar genjang dan segitiga. Uji coba alat peraga melibatkan 281 siswa sekolah dasar. Hasil penelitian menunjukan bahwa alat peraga yang dikembangkan memberikan hasil yang konsisten di berbagai level kelas. Selain itu, alat peraga dan petunjuk penggunaannya juga efektif digunakan dalam pembelajaran daring sehingga dapat dijadikan referensi untuk membantu peserta didik dalam menemukan kembali rumus luas jajar genjang dan segitiga.

**Kata kunci** *Alat peraga, Jajar genjang, Segitiga, Pembelajaran daring, Sekolah dasar*

**Abstract** For elementary school students who are still in the stage of concrete thinking, the concept of area in geometry is an abstract idea. In order to bridge the gap between concrete thinking and abstract thinking, teaching aids such as props are necessary. However, props are mostly used in face-to-face lessons, while the pandemic has forced learning to be conducted online. Employing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), this study developed a prop and instructions for using it to help students understand the area of parallelograms and triangles for online learning. Data for this study were collected through observation, interviews, validation sheets, and tests. The tryout of the props involved 281 elementary school students. The result of the study shows that the developed teaching prop provides consistent results in different classes. In addition, this prop and its manual are also effective for online learning, so teachers can use them as alternatives to assist students in reinventing the formula of the area of parallelograms and triangles.

**Keywords** *Props, Parallelogram, Triangle, Online learning, Elementary school*

## Introduction

Geometry is a branch of mathematics that is taught in elementary schools. This branch is attached to problem solving (Sulistiowati et al., 2019). This branch is important to teach

[1] Department of Mathematics Education, Universitas Mataram, Indonesia, sarjana@unram.ac.id

because activities involved in studying geometry can help develop students' ability to think logically and understand other topics in mathematics (Marchis, 2012; Kennedy et al., 2008).

The geometry that is discussed in elementary school is the two-dimensional shapes found in everyday life (Ahmad, 2021) such as finding the area of parallelograms and triangles. On the other hand, conceptual and procedural learning play an important role in mathematics (Tan-Sisman & Aksu, 2014). However, several studies found that students are not good at understanding the concept of area of 2D shapes because at school they focus more on procedural learning. The majority of students are taught only the procedural method of measuring the area of the shapes by substituting the numbers into the formula (Walton & Randolph, 2017). Students are only trained to use formulas without understanding where the formulas come from (Olivia et al., 2013). Some learning also emphasizes memorizing the formula more than learning the concept (Sarwadi & Shahrill, 2014).

Understanding the concept of area is essential for students because it helps them understand other concepts in mathematics such as surface area and volume (Cavanagh, 2007). Furthermore, the areas of parallelograms and triangles are related to the areas of rectangles. Learning the concept is even more necessary because figuring out the formula and looking at its connection with other formulas is more important than just substituting numbers into the formula. Besides, understanding the concept will minimize the possibility of students getting confused about the difference between what is area and what is perimeter, which leads them to use the wrong formula when solving a problem (van de Walle, 2007). Thus, learning the concept of area is necessary in addition to providing students with procedural learning.

The concept of area is abstract (Sarjana & Sridana, 2020). Meanwhile, students in elementary school are still at the concrete thinking stage (Purwadi et al., 2019; Andriani, 2015). To bridge that gap, a learning aid that is able to illustrate abstract concepts using real objects is necessary. These learning aids are called props (Supatminingsih et al., 2020). A prop such as paper allows students to figure out the formula for the area of a 2D figure because it is concrete and they can touch it (Lestiana & Kurniasih, 2016).

Studies on using props to find formulas for the area of 2D shapes such as parallelograms and triangles in face-to-face classes have been carried out by several researchers (Shavira et al., 2021; Zaqiyah and Caesarina, 2021; Agusta, 2020, Wahyuni et al., 2017). The props used in these studies were equipped with instructions for use. Props and instructions for using them to measure the area of parallelograms and triangles had also been developed in previous research by Sarjana et al. (2018). In that study, they used paper as the prop, and they printed the instructions for use in face-to-face classes. However, a pandemic hit and changed the learning system. During COVID-19, elementary school students in Indonesia are required to study from home, yet the teachers are still obliged to provide a meaningful learning experience for the students (Dewi, 2020). For this reason, it is indispensable to study the use of props and instructions for use in online classes to make sure that students can still learn the concept of geometry regardless of the situation.

This study replicates the research that had previously been conducted by Sarjana et al. (2018). This study focuses on developing props and instructions for use in figuring out formulas for the area of parallelograms and triangles for elementary school students. The problems formulated in this study are: (1) How are the prop and instructions for use that are used to find formulas for the area of parallelograms and triangles developed for online learning? (2) When used in online learning, do the prop and instructions for use that are used to figure out formulas for the area of parallelograms and triangles consistently give the same results to different classes? and (3) is using props and instructions for use to figure out formulas for the area of parallelograms and triangles effective for online learning?

## Theoretical review

Theories that contribute to this research are the theory of props and instructions for use and the theory of how to find the formula for the area of parallelograms and triangles.

### Props and instructions for use

Teaching props help students understand abstract concepts through concrete learning tools that can stimulate their thought, attention, and interest (Supatminingsih et al., 2020). Teaching props provide students with real experience with a real object instead of abstract ideas about concepts because they can directly touch and manipulate the object. Examples of props are: a) school objects that have a rectangular shape, such as a blackboard, notebook, or table, which can be used when the topic is rectangle; b) Pythagorean theorem props from Bhaskara to help students build and figure out the Pythagorean theorem themselves; and c) props to figure out the formula for an odd number series (Suharjana, 2009).

Props are also equipped with instructions for use to ease the use of the props. Figure 1 is an example of instructions for the use of props to find the area of a triangle found in the study conducted by Sarjana et al. (2018).

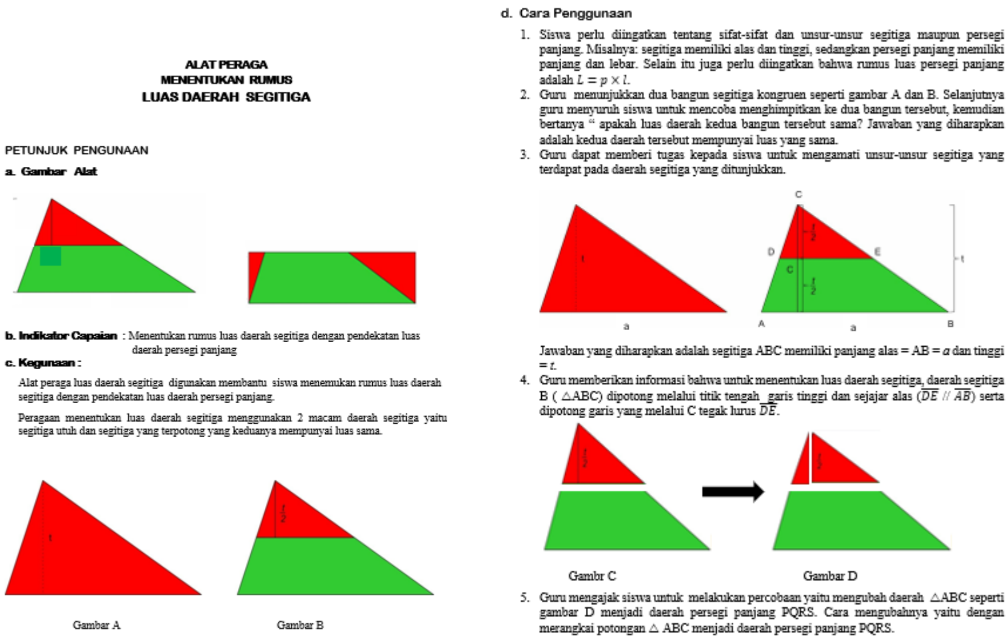


**Figure 1.** An example of instructions for using the prop to find the area of a triangle

### Area of parallelogram

Finding the area of a parallelogram can basically be done by cutting the parallelogram up into some parts, which, if they are put together completely and tightly, will have the same size as the area of the whole parallelogram (Haryani et al., 2015). The basic concept of measuring an area lies in the idea of how a specific unit of measurement can cover a flat surface without gaps and without overlapping each other (Cavanagh, 2007).

There are several ways that can be used to find the formula for measuring the area of a parallelogram. First is to find the area of a parallelogram by finding the area of a rectangle. Second is by finding the area of a parallelogram by finding the area of a triangle (Hoong et al., 2012). The first way is done by; first cutting the parallelogram vertically to make a right-angled trapezium and a triangle, and then taking out the triangle, and finally moving it to the right to form a rectangle from the trapezium. Figure 2 provides an illustration of how to find the area of a parallelogram using the formula used for finding the area of a rectangle.

$$\text{Area of parallelogram} = \text{area of rectangle} = \text{base} \times \text{height length}$$

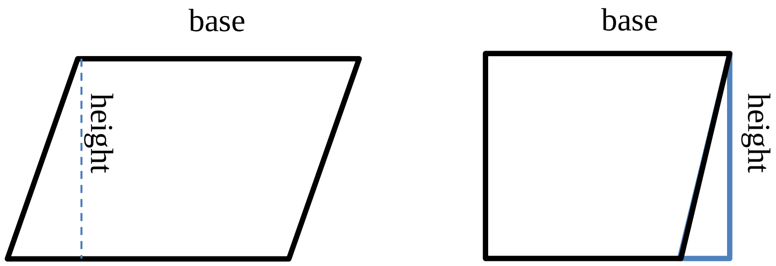


**Figure 2.** How to find the area of a parallelogram using the formula for finding the area of a rectangle

The second way is used to find the area of a parallelogram that has an extreme slope. This is done by cutting the parallelogram into two congruent triangles. Figure 3 shows how to find the area of a parallelogram using the formula for finding the area of a triangle.

$$\text{Area of parallelogram} = 2 \times \text{area of triangle} = 2 \times \left(\frac{1}{2} \times \text{base} \times \text{height}\right)$$
$$= \text{base} \times \text{height}$$

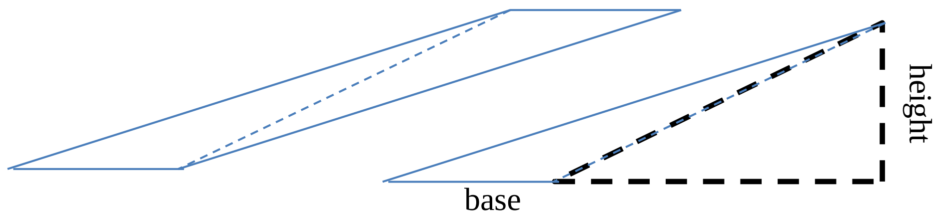


**Figure 3.** How to find the area of a parallelogram using the formula to find the area of a triangle

## Area of triangle

There are several types of triangles, including isosceles triangles and right triangles. The more types of triangles there are, the more ways there are to find the area of those triangles. There are two ways to measure the area of a triangle, including a) changing the shape of the triangle to another measurable shape without changing its area, and b) making another shape by doubling the area of the triangle (Takahashi et al., 2006). Figure 4 shows an illustration of the first way to find the formula for the area of an isosceles triangle.

$$\text{Area of triangle} = \text{area of rectangle} = \text{length} \times \text{width} = \frac{1}{2}\,\text{base} \times \text{height}$$

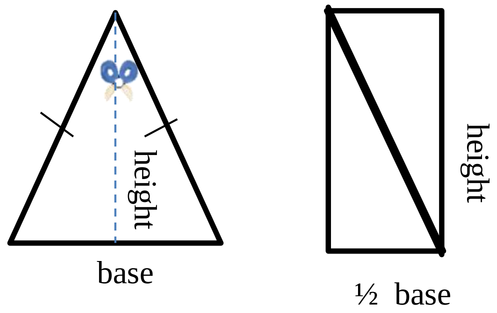


**Figure 4.** Finding the area of an isosceles triangle by changing the shape of the triangle to another measurable shape without changing its area

Additionally, Figure 5 presents an illustration of how to find the formula for the area of an arbitrary triangle by cutting it into several parts and then rearranging them to form a rectangle, which students have learned beforehand.

$$\text{Area of triangle} = \text{area of rectangle} = \text{length} \times \text{width} = \text{base} \times \frac{1}{2}\text{heigth}$$
$$= \frac{1}{2} \times \text{base} \times \text{height}$$

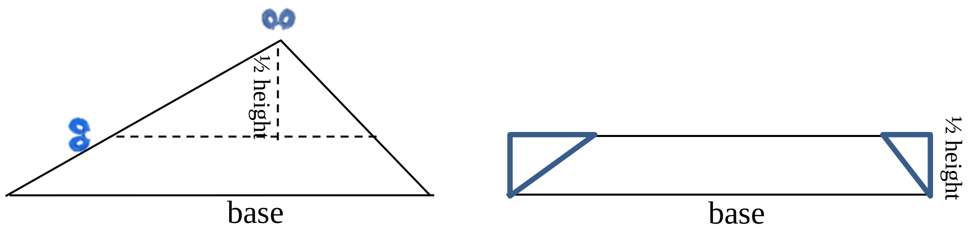


**Figure 5.** Finding the area of an arbitrary triangle by changing the shape of the triangle to another measurable shape without changing the area

Another way to find the area of a triangle is by doubling the triangle itself. The illustration can be seen in Figure 6.

$$\text{Area of triangle} = \frac{1}{2}\,\text{area of rectangle} = \frac{1}{2} \times \text{base} \times \text{height}$$

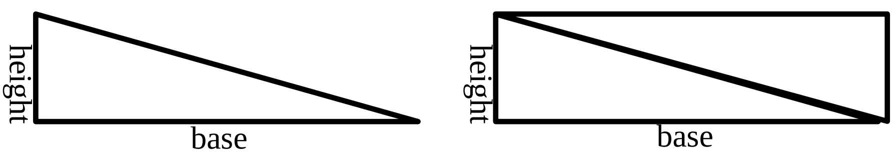


**Figure 6.** Finding the area of a triangle by doubling the area of the triangle itself and make another shape

## Methods

The research was conducted using the ADDIE model, considering that this method was suitable to develop a design in the field of education (Aldoobie, 2015). This model consists of five stages: Analysis, design, development, implementation, and evaluation (Alodwan & Almosa, 2018). Below are the steps in developing the prop to measure the area of a parallelogram and a triangle, along with instructions for use using the ADDIE model:

- Analysis
  In this stage, the teaching material that needed developing was analyzed (Serevina et al., 2018). It included analyzing the needs, students, and content (Durak & Ataizi, 2016). The analysis was carried out through interviews, observation, and literature studies (Sriwahyuni et al., 2021). The result of the observation and interview indicated that elementary school teachers in Mataram did not have the same understanding about applications used in online learning as well as props and instructions for use. Therefore, it is inevitable to develop one, especially for measuring the area of parallelograms and triangles. For this reason, nine classes from three different districts, Cakra, Mataram, and Ampenan, were chosen to be the subjects of the study. These classes were chosen because they were considered ready to carry out online learning. All students and teachers involved in this study had smartphones that supported online learning.
- Design
  This stage was used to design strategies to solve the problems found in the analysis stage. To solve the problem, at this stage, the researchers modified the design of the prop and instructions for use that had previously been used by Sarjana et al., 2018 in face-to-face classes. In previous research, the instructions for use were printed and made only for teachers. But, for online classes, the instructions for use were made in the form of a video. Therefore, the students could do the activities as instructed in the video, such as cutting and pasting the papers, etc.
- Development
  At this stage, the video was complete and ready to be validated by experts and practitioners using the Likert scale. The video was validated by two experts to check the appropriateness of the instructions for use. The video was also validated by nine teachers, as they would be the ones using it. These teachers tested the practicality of the video for their online classes. The data was then processed using the following formula:

  $$\text{Percentage score} = \frac{\sum \text{gained score}}{\sum \text{maximum score}} \times 100\%$$

  The results were interpreted as follows (Sugiyono, 2013):

**Table 1.** Interpretation of Likert scale

| Percentage | Interpretation |
|---|---|
| 0%-25% | Extremely inappropriate |
| 26%-50% | Inappropriate |
| 51%-75% | Appropriate |
| 76%-100% | Extremely appropriate |

- Implementation
  At this stage, the prop and instructions for use were used in online classes. At the end of the lessons, a test was administered to see the students understanding of the area of parallelograms and triangles. The suitability of the test content with the learning objectives had also been validated in advance by experts.
- Evaluation
  At this stage, the consistency and effectiveness of the prop and instructions for use were evaluated. The students answer sheets were checked and analyzed. Additionally, an inferential statistic was also employed in this study to find out the consistency of the prop and the instructions for use by checking whether there were differences in students scores after using the prop and instructions for use to measure the area of parallelograms and triangles. The inferential statistic used was ANOVA. However, if the prerequisites for the ANOVA test, such as normality and homogeneity of the data, are not met, then the data will be processed using the Kruskall-Wallis test (Yusof et al., 2013). The students test results were also analyzed based on the achieved criteria of maximum completeness (KKM), which were different in each district. KKM in schools in Cakra, Mataram, and Ampenan were 68, 70, and 70, respectively. The prop is considered effective if the completeness is greater than 80%, which means that more than 80% of the students should achieve the KKM prescribed by each school.

## Findings and Discussion

The video containing the instructions for use was made before the prop was used in the classes. Figure 7 shows a video snapshot containing instructions for use.

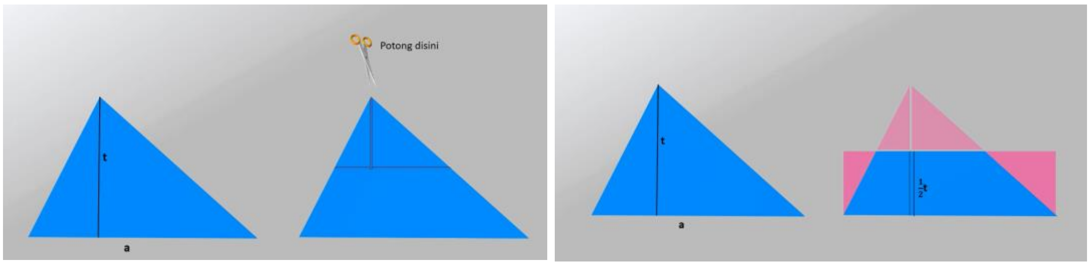


**Figure 7.** Video snapshots containing instructions for using the prop

Figure 7 shows snapshots of instructions for using the prop to find the formula for the area of a triangle. The snapshots show a video showing a demonstration of which parts to cut and move so they can form a rectangle. Before it was used, two experts and nine teachers validated the video in terms of its content.

Table 2 shows the average validation scores given by the experts and teachers. The average validation scores were more than 4 out of 5, which means that the video was deemed valid and ready to be used.

The following is an example of how four teachers used the prop, the video, in their online learning. The steps were as follows:

1) Pre-Activity: At this stage, the teacher imparted motivation, apperception, and learning objectives by giving the students examples of 2D figures found in everyday life. The

teacher then asked the students questions through a video. Students are led to understand the material about the area of a parallelogram. The teacher first told the students that a parallelogram has sides, i.e., height *h* and base *b*, and that a rectangle also has sides called length *l* and width *w*.

**Table 2.** The result of validation

| The party doing the validation | Score average | Percentage | Interpretation |
| --- | --- | --- | --- |
| Experts in terms of the material | 4.5 | 90% | Extremely appropriate |
| Teachers as practitioners | 4.3 | 86% | Extremely appropriate |

2) Whilst Activity: At this stage, students were explained how to determine the area of a parallelogram using the formula for measuring the area of a rectangle. This means cutting some parts of the parallelogram in such a way that the parts, if rearranged, would form a rectangle. After that, the teacher directed the students to practice some steps using a parallelogram prop made from colorful origami paper. The following are the steps that the students had to follow.

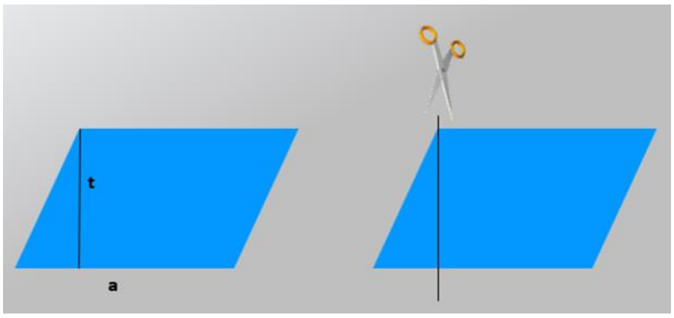


**Figure 8.** Cutting paper with scissors perpendicularly to get a right-angled triangle

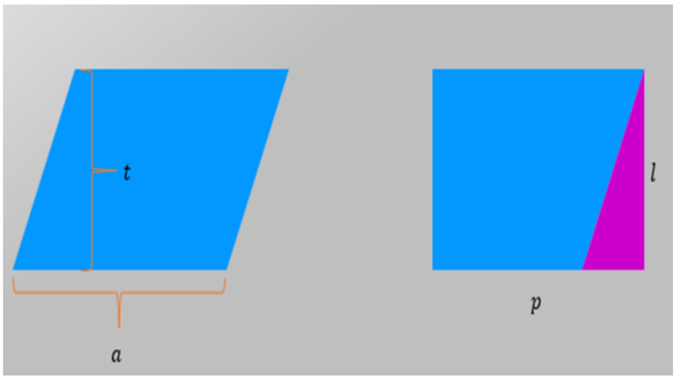


**Figure 9.** Both parts were then put together to form a rectangle

Furthermore, the teacher asked some students to demonstrate the results they got, and other students gave responses. In this activity, students were very enthusiastic and actively participated. Through this live activity, students were expected to be able to figure out the concept of the area of a parallelogram, which means improving their abstract thinking skills.

Task 1. Determine the relationship between *l* and *b* and *w* and *h*!
with, $l$ = …..
$w$ = … …
*From the experiment, it was found that:*
*Area of parallelogram = Area of rectangle*
= $l \times w$
= ……………………….
*Conclusion.*
*The area of the parallelogram with height h and base b is*
$A$ = ………………….

3) Post Activity: At this stage, the teacher guided the students to draw conclusions and evaluated the lesson.

The video was used by the students who studied online. Then, at the end of the lessons, a test was administered to measure students' comprehension of the area of parallelograms and triangles. The test results were then analyzed to determine the consistency of the video for different classes. First, a homogeneity prerequisite test was carried out by employing SPSS 21. The results of the homogeneity test are presented in Table 3.

**Table 3.** Results of homogeneity test

| Levene statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 3.615 | 8 | 272 | .001 |

Table 3 shows that sig = 0.001. This sig score is smaller than the significance of $\propto$=0.05 which means that the test results from the nine classes were not homogeneous. Therefore, data should be tested using the Kruskall-Wallis test. Table 4 shows the results of the Kruskall-Wallis test.

**Table 4.** Results of the Kruskall-Wallis test

| | Test score |
|---|---|
| Chi-Square | 12.460 |
| df | 8 |
| Asymp. Sig. | .132 |

Table 4 shows that the asymp. sig is 0.132. This score is greater than the significance of $\propto$=0.05. This means that there was no difference in the students' test results, so it can be concluded that the prop and instructions for use provided consistent results in different classes.

The students test results were also analyzed to find out the effectiveness of the prop and the instructions for its use. The effectiveness is determined based on the KKM achieved.

Students are deemed to have completed the lesson if their test scores are at least the same as the KKM. Table 5 shows the students completing the lessons in each district.

**Table 5.** The students completing the lessons in each district

| Data | Cakra (KKM=68) | | | Mataram (KKM = 70) | | | Ampenan (KKM =70) | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | A | B | C | A | B | C |
| Number of students | 30 | 30 | 30 | 31 | 30 | 32 | 36 | 30 | 32 |
| Students completing the lesson | 26 | 25 | 25 | 26 | 25 | 26 | 32 | 26 | 28 |
| Percentage of students completing the lesson | 87% | 83% | 83% | 84% | 83% | 81% | 89% | 87% | 88% |

Table 5 shows that the students who complete the lesson in each class are more than 80%. This means that learning the area of parallelograms and triangles using the prop and instructions for use was effective. This was because the prop provided meaningful learning for students (Agusta, 2020). Learning is said to be meaningful if it provides opportunities for students to become actors in the learning process (Muchlis et al., 2018). In this study, the students were actively involved in learning, cutting, and manipulating the prop used (Abbas & Zakaria, 2018). Figure 8 shows a student was manipulating the prop.

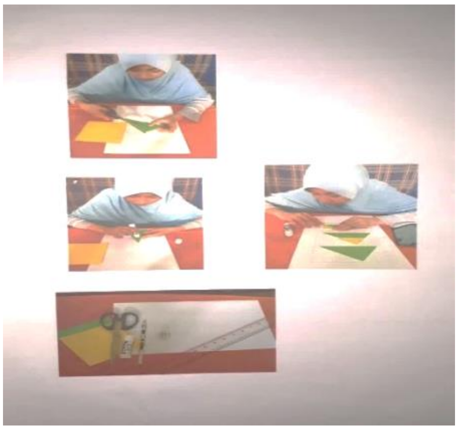

**Figure 10.** A student was manipulating the Prop

Figure 10 shows that the student is manipulating a touchable prop made of paper. This prop helped illustrate the information conveyed in the lesson, especially in the video showing how to use the prop. The students gained direct experience cutting and pasting triangles into other shapes in order to find the formula for the area of a triangle. Furthermore, Figure 11 shows the results of the manipulation of the prop by a student. It reveals that in order to find the formula for the area of a triangle, the student cut the arbitrary triangle into three parts: two right-angled triangles (yellow) and one trapezium (green). The condition is that the triangle and trapezium should have the same height, which is 12 times the height of the initial triangle. These figures were then assembled to form a rectangle. Finally, the student drew a conclusion about how to measure the area of the triangle using the formula for the area of the rectangle. These activities helped optimize the function of all five senses for the students by seeing, touching, and using their minds logically so that the learning became more effective (Widiyatmoko, 2013).

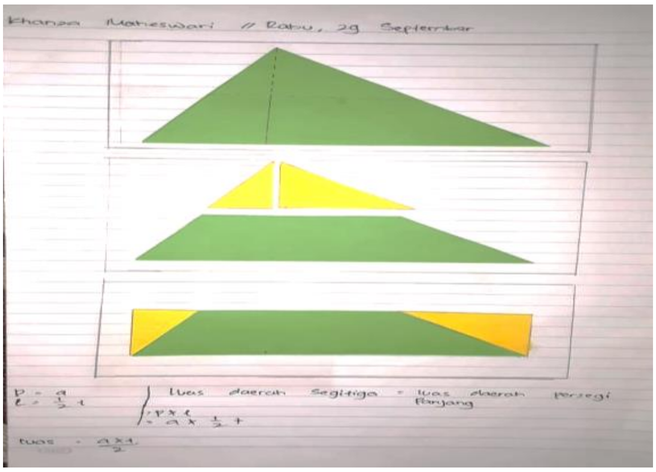


**Figure 11.** The results of a manipulation by a student in finding the formula for the area of a triangle

## Conclusion

The prop and instructions for using it to find the formula for the area of a parallelogram and a triangle were made in the form of a video. That video was used for online lessons, and it provided a consistent result for various different types of classes. This means that this video could also be used in other online classes. Furthermore, this video helps students fully comprehend the concept of the area of parallelograms and triangles. Therefore, the teachers could use this prop to bridge the students concrete and abstract thinking, such as in finding the area of parallelograms and triangles in face-to-face or online lessons.

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