

# DEVELOPING PROBLEM BASED LEARNING DIGITAL WORKSHEET TO LEARN TRIANGLE: A VALIDITY STUDY

Ratna Marlina<sup>1</sup>, Nida Fathiya Hanifah<sup>2</sup>, Nelly Fitriani<sup>3</sup>

<sup>1</sup>IKIP Siliwangi, Jl. Terusan Jenderal Sudirman, Cimahi, Indonesia.  
[ratnamarlina@student.ikipsiliwangi.ac.id](mailto:ratnamarlina@student.ikipsiliwangi.ac.id)

<sup>2</sup>IKIP Siliwangi, Jl. Terusan Jenderal Sudirman, Cimahi, Indonesia.  
[nidnfhani@gmail.com](mailto:nidnfhani@gmail.com)

<sup>3</sup>IKIP Siliwangi, Jl. Terusan Jenderal Sudirman, Cimahi, Indonesia.  
[nhe.fitriani@gmail.com](mailto:nhe.fitriani@gmail.com)

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## ABSTRACT

Students' understanding of triangle perimeter and area is crucial, as these concepts form a foundational basis for more advanced mathematical learning. However, in practice, the availability of engaging and innovative learning materials remains limited, with teachers typically relying on standard textbooks that often do not fully support conceptual understanding. This study aimed to evaluate the validity of a Problem-Based Learning (PBL)-based digital worksheet designed to enhance learning on triangle perimeter and area. The research applied the 4-D development model (Define, Design, Develop, Disseminate), although only the first three stages were implemented due to time constraints. The participants consisted of four mathematics teachers from the West Bandung area, serving as expert validators. Data were collected using a material expert validation questionnaire with 17 items assessing content accuracy, relevance, and instructional suitability. Descriptive analysis was conducted by calculating the percentage of positive responses for each indicator and interpreting them according to predefined validity criteria. The results showed that alignment with learning objectives scored 83%, material appropriateness 86%, alignment with student characteristics 80%, theoretical suitability 90%, alignment with learning styles 83%, and environmental suitability 93%. The overall validity of the digital worksheet reached 86%, categorized as very valid, indicating its suitability for supporting learning activities and the implementation of the PBL model. In conclusion, the PBL-based digital worksheet demonstrates strong validity and potential to improve students' understanding of triangle perimeter and area. Further research is recommended to examine its practicality and effectiveness in real classroom settings.

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### Corresponding Author:

Ratna Marlina,  
Department of Mathematics Education,  
Institut Keguruan dan Ilmu Pendidikan Siliwangi,  
Jl. Terusan Jend. Sudirman, Cimahi, Indonesia  
Email: [ratnamarlina@student.ikipsiliwangi.ac.id](mailto:ratnamarlina@student.ikipsiliwangi.ac.id)

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## INTRODUCTION

Education plays a vital role in efforts to enlighten the nation's intellectual life. One of the initiatives undertaken by the government to achieve this goal is curriculum reform (Hakim & Murtafiah, 2020). This aligns with Hendriana et al (2022), who state that it is important to develop innovative and creative individuals while maintaining the values of humanism and

nationalism. Mathematics is a scientific discipline that consists of structured concepts, logic, and proven propositions that operate systematically and logically across all fields of study (Marliani, 2015). Therefore, geometry, particularly quadrilaterals and triangles, constitutes an essential component of mathematics learning.

The topics of squares and triangles are considered prerequisite materials in mathematics. According to Fadhilah et al (2020) triangle material, which is part of geometric constructions in two-dimensional figures, represents an abstract concept. Meanwhile, Kamilah & Imami (2020) explain that triangles are a branch of geometry that is widely applied in everyday life and also serves as foundational knowledge for learning other three-dimensional shapes such as cubes, rectangular prisms, pyramids, and others. Learning triangle material is important because it develops students' spatial reasoning, logical thinking, and problem-solving skills, which are essential competencies in mathematics and other STEM fields. In contrast to these views, Hadiyanto et al (2020) state that triangle material includes the properties of squares, the concepts of area and perimeter of squares, the concept of triangles, and classifications of triangles based on sides and angles. Mastery of these concepts ensures students can accurately apply mathematical principles in both academic and real-world contexts, making triangle learning fundamental in the mathematics curriculum.

Therefore, the concepts of the area and perimeter of triangles are important to be taught at both primary and secondary education levels. However, in practice, students still experience difficulties in mastering these concepts. According to Sumiati & Agustini (2020), several learning obstacles are commonly found, including students' difficulty in understanding word problems, their inability to construct mathematical models from the given problems, and their limited competence in translating real-world situations into mathematical representations. These challenges indicate the need for innovative learning approaches and supportive instructional materials that can scaffold students' understanding of abstract geometric concepts.

One alternative solution to address these challenges is the implementation of Problem-Based Learning (PBL). PBL is considered an active learning approach because it emphasizes student engagement, where learners construct their own understanding through interaction with their surrounding environment. Problem-based learning has been shown to be effective in enhancing students' creative thinking skills (Ernawati et al., 2022). This approach promotes student-centered learning and encourages learners to actively construct knowledge through meaningful experiences. Through PBL, students are expected to become more motivated and improve their scientific literacy skills by engaging in problem-solving processes. Furthermore, the problems presented should be contextualized in real-life situations, as authentic problems facilitate meaningful learning and contribute to improved understanding and learning outcomes (Triani et al., 2018). The stages of learning using the PBL model include problem orientation, organizing students for investigation, guiding the investigation, developing and presenting the results, and analyzing and evaluating the problem-solving process.

According to Desrinelti & Miaz (2022) in addition to the PBL approach, adequate instructional support is required to ensure the successful implementation of this learning model. One essential supporting teaching material is the Student Worksheet (LKPD), which serves as an activity sheet designed to facilitate hands-on learning experiences, requiring students to apply their knowledge through structured tasks. LKPD functions as a learning guide provided by educators in the form of instructions or directions for completing learning activities. Sari et al (2020) define LKPD as a guide or manual for conducting exercises that aim to improve students' knowledge and skills through observation and demonstration. Furthermore, LKPD enhances students' cognitive engagement and responsibility during the learning process. Mulyani and Farida (2020) state that LKPD plays a strategic role in fostering critical thinking by guiding students in reasoning through problem-solving activities designed by teachers.

Recent studies have shown that digital worksheets, when integrated with the PBL model, can significantly improve students' understanding of mathematics concepts by providing interactive exercises, immediate feedback, and real-world problem scenarios. For example, Munawaroh & Sholikhah (2022) developed an interactive PBL-based LKPD and found that its use, supported by interactive videos and Google-based platforms, effectively stimulated students' critical thinking skills. Similarly, Nuryoko (2022) reported that the use of interactive E-LKPD integrated with the PBL model significantly improved students' critical thinking abilities, with a high category of improvement. These findings are further reinforced by Ningsyih et al (2018), who concluded that problem-based worksheets positively contribute to the enhancement of students' critical thinking skills.

Therefore, this study aims to develop and evaluate a PBL-based digital worksheet specifically designed for learning the area and perimeter of triangles. The study's purpose is to provide an effective instructional media that addresses students' learning difficulties, enhances engagement, and fosters critical thinking skills in mathematics. By bridging the identified learning problems with a PBL digital solution, this research seeks to contribute to improving both teaching practices and students' conceptual understanding of geometric concepts.

## **METHOD**

This study employed a research and development (R&D) design. In this development process, the researchers focused on creating mathematics teaching materials based on the Problem-Based Learning (PBL) model by modifying the 4D development model proposed by Thiagarajan. At the define stage, curriculum analysis, needs analysis, and learner analysis were conducted. At the design stage, the researchers designed the research instruments and developed a PBL-based mathematics e-module for junior secondary school students. During the development stage, the researchers designed the worksheet and subsequently conducted a validity assessment with three subject-matter experts. The validators were selected through purposive sampling from West Bandung Regency and were professional teachers with over seven years of teaching experience, currently instructing eighth-grade students on triangle-related topics. Due to time constraints, the researchers conducted the study up to the Develop stage, with the Disseminate stage reserved for future implementation, ensuring a comprehensive development and validation of the digital worksheet prior to large-scale application. The research subjects consisted of eighth-grade students from a junior high school located in the West Bandung Regency area. In this study, the data collection technique employed was an expert feasibility questionnaire, with the assessment instrument in the form of a teaching material evaluation sheet using a Likert scale ranging from 1 to 5. In this case, the researcher did not modify the Likert scale or eliminate the neutral option, as the scale was intended for teachers, for whom the likelihood of choosing a neutral response was considered minimal.

The data analysis technique applied descriptive measures of central tendency, namely median, mode, and frequency. The researcher avoided using the mean as a measure of central tendency, considering that the Likert scale produces ordinal data, and ordinal data cannot be summed or subjected to mathematical operations; therefore, the use of mean statistics was deemed inappropriate. To calculate the percentage of each indicator in the expert validation sheet, the frequency of positive responses was used.

$$PP = \frac{f}{n \times \sum Q} \times 100\%$$

*PP* = Percentage of positive responses

*f* = the frequency of responses for each questionnaire item

*n* = total respondents

$\Sigma q$  = the number of items in each indicator

After the percentage score of the validity test conducted by expert validators was obtained using the formula above, the percentage results were then classified according to the criteria presented in the table below.

**Table 1.** Interpretation Criteria for Expert Validity Scores

Interval	Interpretation
85.01% – 100%	Very valid; the product is appropriate for use without revision
70.01% – 85.00%	Valid; the product is appropriate for use with minor revision
50.01% – 70.00%	Low validity; the product is not recommended for use and requires major revision
1.00% – 50.00%	Invalid; the product is not suitable for use

Source: Akbar (Juniati et al., 2021)

## RESULTS AND DISCUSSION

### *Results*

This section presents various findings from the development research of a digital worksheet on triangle area and perimeter based on the Problem-Based Learning (PBL) model. The research results were obtained through assessments conducted by three expert validators from West Bandung Regency who are professionally qualified teachers. These findings provide an overview of the quality of the developed digital worksheet based on the 4D development stages and demonstrate its potential as an innovative teaching material that can be accessed and implemented by teachers in the learning process.

### **Define**

At this stage, observations were conducted in one junior high school located in West Bandung Regency with the aim of analyzing learning needs, reviewing the curriculum, and examining student characteristics. The data collection techniques involved classroom observations and interviews with teachers. Based on the teachers' explanations, there were no innovative teaching materials available, resulting in teachers relying heavily on the standard textbooks provided by the school. One of the main challenges faced by teachers in developing worksheets was the lack of comprehensive information regarding appropriate (valid) and innovative instructional material development concepts. This condition indicates a clear need for the development of innovative teaching materials, particularly digital worksheets.

Furthermore, the researcher analyzed the curriculum to identify topics that posed difficulties for students, one of which was triangle area and perimeter. The interview results with both teachers and students revealed that most students experienced difficulties in understanding the concepts of triangle area and perimeter and some also struggled with computational procedures related to these topics. Conceptually, students often had difficulty distinguishing between the base and the height of a triangle, as many assumed that the base must always be positioned at the bottom. To address this issue, learning activities were initiated using contextual problems, such as a triangular-shaped garden. This context challenged students' assumption that the base is always located at the bottom, as the triangular park did not clearly indicate a "bottom" position. Consequently, students were required to apply accurate conceptual understanding in solving the problem. Therefore, contextual problem-based learning was deemed necessary to support students in constructing correct mathematical concepts, leading the researcher to adopt the characteristics of the PBL model in designing the digital worksheet.

The next step involved analyzing students' characteristics. In general, students belong to Generation Z, who are already accustomed to using technology, particularly smartphones.

Although the topic of triangle area and perimeter is taught in Grade VIII, several Grade IX students were interviewed as they had already learned the material. The interview results indicated that students had never experienced technology-based learning. According to the mathematics teacher, this was due to the limited availability of projectors and the extensive preparation required, making such implementation inefficient unless using personal gadgets. Based on this analysis, there was a need for teaching materials that are easily accessible and efficient to use. Therefore, the researcher chose to develop a digital worksheet assisted by the Canva application, as it was considered relevant to these conditions, the link can be accessed at <https://bit.ly/E-LKPDsegitiga>.

## Design

At the design stage, the researcher designed a digital worksheet as a solution to students' difficulties in learning the concepts of triangle area and perimeter. The development process utilized the Canva platform, as it provides a wide range of attractive templates and is easy to operate. The completed design was then shared via a link that directs users to the digital worksheet. Consequently, the worksheet was not printed but accessed through smartphones or laptops using the link provided by the researcher. The following is the design of the digital worksheet developed by the researcher:



**Figure 1.** Initial Interface Design of the Digital Worksheet

In the initial display, the cover presents the title *Student Worksheet (LKPD)* using a PBL learning model for triangle material. The philosophy behind the selected colors conveys meaningful symbolism: yellow represents hope, orange symbolizes self-confidence, green signifies growth, and blue reflects calmness. Therefore, this worksheet is expected to support the learning process by fostering a calm learning atmosphere while also strengthening students' self-confidence in solving mathematical problems.

On the second display, the learning objectives are presented, namely: identifying and understanding the formula for the perimeter of a triangle, calculating the perimeter of a triangle through example problems, and solving problems involving the perimeter of triangles. Furthermore, the task instructions begin with several key points, including: starting with a prayer, carefully reading the worksheet, engaging in group discussions to understand the concepts, completing each step in the group tasks, asking and discussing with the teacher when difficulties arise, and presenting the group work results in front of the class.

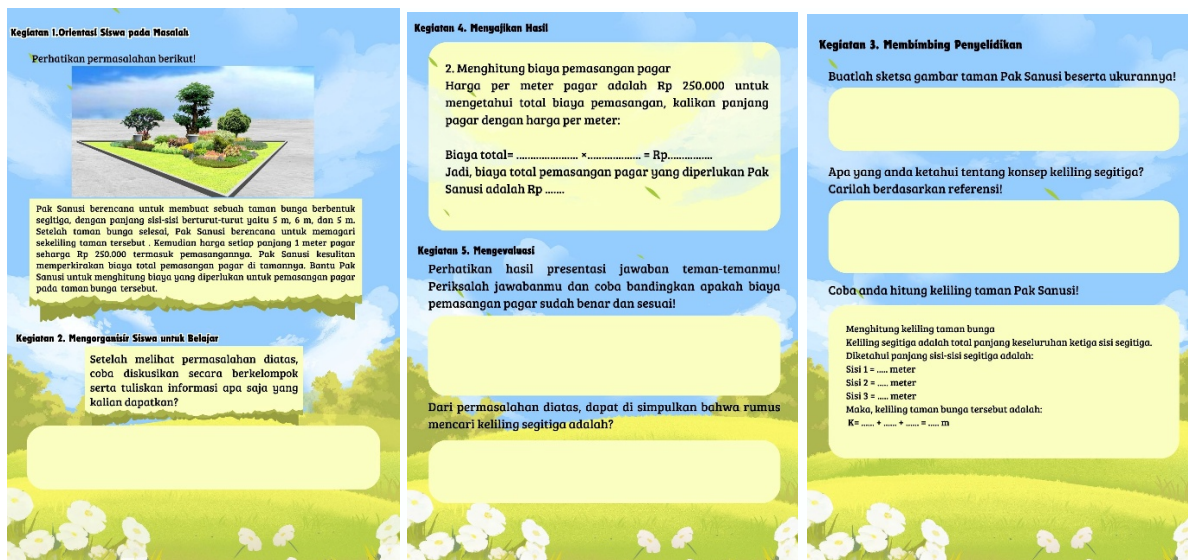


Figure 2. Digital Worksheet Design for Triangle Perimeter Material

Figure 2 presents the design of the digital worksheet for triangle perimeter using the stages of Problem-Based Learning (PBL). The problem context involves a plan to fence a triangular flower garden with side lengths of 5 m, 6 m, and 5 m, with a cost of IDR 250,000 per meter, including installation fees. To solve this problem, students are required to illustrate the situation and calculate the total length of the sides surrounding the garden. Through the PBL stages embedded in the digital worksheet, students are guided to discover and understand the concept of the perimeter of a triangle.

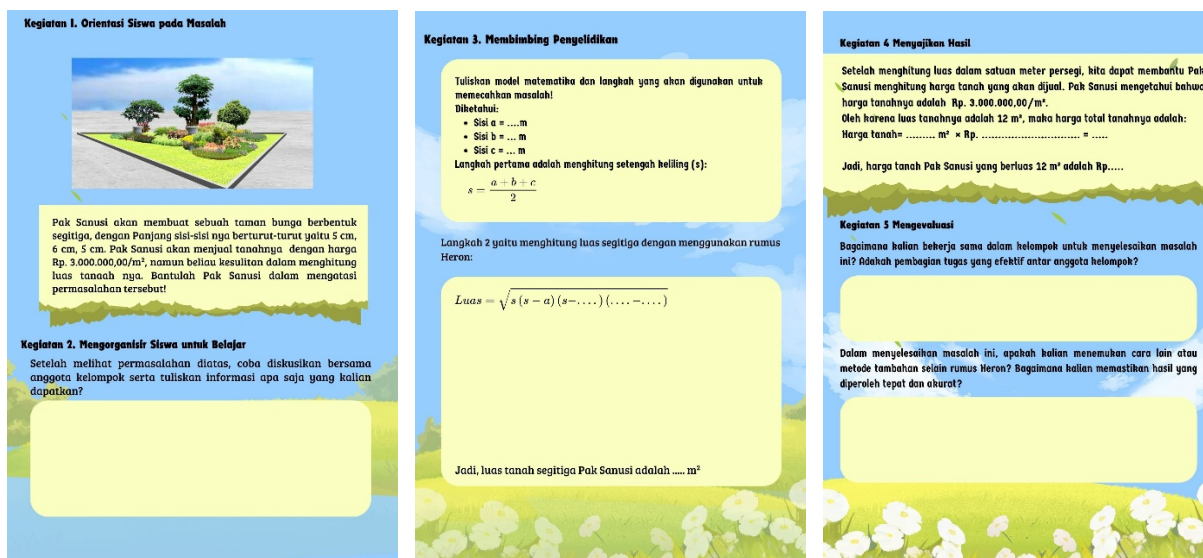


Figure 3. Digital Worksheet Design for the Topic of Triangle Area

Figure 3 shows the design of the digital worksheet on triangle area using the stages of Problem-Based Learning (PBL), starting from orienting students to the problem, organizing students for learning, guiding the investigation, presenting results, and evaluating the solution process. The problem context applied involves the sale of a triangular flower garden with side lengths of 5 m, 6 m, and 5 m, where the price per square meter is IDR 3,000,000. In this context, the landowner experiences difficulty in calculating the area, allowing students to indirectly learn how to assist others in solving real-life problems. This context helps students discover the concept of triangle area and apply it in problem-solving. It is expected that this approach fosters

students' social awareness and encourages them to help one another in addressing everyday problems.

**Develop**

In this study, a PBL-based digital worksheet was developed and its validity was evaluated by expert validators consisting of four mathematics teachers from West Bandung and Purwakarta. The validation data obtained from these experts were then analyzed to determine the level of validity of the teaching material. The results of the validity assessment from the expert validators are presented in the following table:

**Table 2.** Descriptive Statistical Analysis of Data from Three Subject Matter Expert Validators

No	Indicator	Median	Mode
1	Alignment with learning objectives	5	5
2	Relevance to the subject matter	4	4
3	Compatibility with students' characteristics	4	4
4	Consistency with theoretical framework	5	5
5	Suitability with learning styles	5	5
6	Compatibility with the learning environment	5	5
Overall Summary		<b>5</b>	<b>5</b>

Table 2 presents the assessment results of the three subject matter expert validators based on the following indicators: alignment with learning objectives, relevance to the subject matter, compatibility with students' characteristics, consistency with theoretical framework, suitability with learning styles, and compatibility with the learning environment. The data were analyzed using descriptive statistics focusing on measures of central tendency, namely the median and the mode. Overall, the median value is 5, indicating that more than 50% of the validators responded very positively to various aspects of the feasibility of the developed digital worksheet. In addition, the overall mode value is also 5, meaning that the majority of validators shared the same perception, where each feasibility criterion was rated at the highest level.

More specifically, as shown in Table 2, the indicators of alignment with learning objectives, theoretical framework, learning styles, and learning environment each obtained a median and mode value of 5, indicating that the digital worksheet was rated as very good by all validators. Meanwhile, the indicators of relevance to the subject matter and compatibility with students' characteristics obtained a median and mode value of 4, which indicates that most validators considered these aspects to be good, although they still have potential for further improvement. Therefore, overall, the validation results from the three experts indicate that the developed digital worksheet has a high level of feasibility and is appropriate for use in the learning process. However, it should be noted that certain aspects related to subject matter relevance and compatibility with students' characteristics still have potential to be optimized for better quality.

Furthermore, the digital worksheet was analyzed in greater depth by presenting the percentage of each validator's responses to provide a more comprehensive overview. This analysis aims to reveal the tendency of the validators' assessments for each indicator in a more detailed manner. The categorization of the assessment is presented in the following table:

**Table 3.** Percentage Frequency of Responses from Three Validators

No	Indicator	Percentage of Assessment by Three Validators					Positive Response	Interpretation
		1	2	3	4	5		
1	Alignment with learning objectives	0%	0%	0%	44%	56%	100%	Very Valid
2	Relevance to the subject matter	0%	0%	0%	53%	47%	100%	Very Valid
3	Compatibility with students' characteristics	0%	0%	0%	100%	0%	100%	Very Valid
4	Consistency with theoretical framework	0%	0%	0%	33%	67%	100%	Very Valid
5	Suitability with learning styles	0%	0%	0%	33%	67%	100%	Very Valid
6	Compatibility with the learning environment	0%	0%	0%	17%	83%	100%	Very Valid
<b>Average</b>							<b>100%</b>	<b>Very Valid</b>

Based on the assessment results from three validators across six product feasibility indicators, it was found that all aspects received a 100% positive response, categorized as very valid. This indicates that the developed product has met all the assessed feasibility criteria. For the indicator of alignment with learning objectives, 44% of the validators gave a score of 4 and 56% gave a score of 5, meaning that all validators agreed the product is highly aligned with the intended learning objectives. This suggests that the content and activities within the product support the achievement of both basic competencies and expected learning outcomes.

The indicator of relevance to the material also showed very good results, with 53% of validators giving a score of 4 and 47% a score of 5. This finding illustrates that the presented material is aligned with the curriculum, relevant to the mathematical concepts being taught, and systematically structured according to students' level of ability. Furthermore, the indicator of compatibility with students' characteristics achieved a perfect result, with 100% of validators giving a score of 4. This shows that the product was developed by considering students' characteristics, including their cognitive development level, learning interests, and prior knowledge of the material.

For the indicator of consistency with theory, 33% of validators gave a score of 4 and 67% gave a score of 5. This result indicates that the developed product is grounded in relevant learning theories, such as constructivist theory, contextual learning, and culturally-based learning theories underlying the instructional design. The indicator related to suitability with learning styles showed that 33% of validators gave a score of 4 and 67% gave a score of 5. Thus, the product is considered capable of accommodating diverse student learning styles, such as visual, auditory, and kinesthetic, through interactive and multimodal material presentation. The final indicator, compatibility with the learning environment, obtained 17% with a score of 4 and 83% with a score of 5. This means that the product is considered appropriate to the students' learning environment, in terms of cultural context, school setting, and real-life situations relevant to mathematics learning.

Overall, the average validation result reached 100% with a very valid category. This indicates that the developed product meets high standards of content feasibility, visual appearance, and theoretical as well as pedagogical appropriateness. Therefore, the product is deemed feasible and appropriate for use without significant revision and can proceed to the limited trial or field

implementation stage to assess its practicality and effectiveness in improving student learning outcomes.

### ***Discussions***

Teaching materials, in this case the digital worksheet, constitute an important component in the learning process to support the achievement of established learning outcomes. The digital worksheet is considered appropriate if it fulfills the indicators of instructional material assessment as evaluated by subject-matter experts, thereby allowing it to be categorized as valid. Overall, the results from expert evaluations indicate that the product falls into the very valid category. According to Akbar (Juniati et al., 2021), the criterion of very valid signifies that the developed product can be used without revision. This finding aligns with the study by Munawaroh & Sholikhah (2022), who reported that PBL-based interactive worksheets effectively stimulated students' critical thinking skills, demonstrating that expert-validated materials enhance instructional quality. Recent research indicates that effective digital worksheets significantly enhance student motivation and engagement, thereby improving overall academic performance in diverse learning contexts (Alfira et al., 2024). Similarly, Nuryoko (2022) found that interactive E-LKPD integrated with PBL improved students' critical thinking and engagement, supporting the current result that the developed digital worksheet facilitates active student participation.

By incorporating multimedia elements and interactive features, these worksheets can cater to various learning styles and needs, making them a valuable resource in modern education (Sari et al., 2024). This indicates that the digital worksheet is suitable for implementation and is expected to assist students in understanding the concepts of triangle perimeter and area. This is consistent with findings by Ningsyih et al (2018), who concluded that problem-based worksheets with interactive features significantly enhanced students' understanding and problem-solving abilities. One of the fundamental aspects in designing teaching materials is the substance of the content. There are two indicators used to measure the substance of the material. First, the indicator of alignment with learning objectives shows that the average score from experts falls into the valid category, while the second indicator, namely content suitability, is rated as very valid. In line with this, Anggraini et al (2024) stated that a valid worksheet implies that it is feasible for use, meets good content standards, and is highly appropriate as a teaching material. Furthermore, according to Heleni et al (2023), a valid and practical worksheet provides guidance indicating that the product output can serve as a reference in the learning process. The digital worksheet on the topic of triangle perimeter and area serves as a guideline for researchers or teachers who intend to apply it in classroom instruction. This agrees with the results of Sari et al (2024), who highlighted that interactive digital worksheets help teachers plan and deliver instruction effectively while supporting student-centered learning.

The developed digital worksheet specifically supports learning the concepts of triangle perimeter and area. It provides structured activities that help students construct knowledge through problem-solving, consistent with the PBL approach. In line with Triani et al (2018), who demonstrated that contextualized and problem-based learning materials improve conceptual understanding in mathematics, this study confirms that well-designed digital worksheets can bridge the gap between abstract concepts and students' real-life problem-solving abilities. This is particularly important in the learning process, as the role of the digital worksheet becomes the foundation for teaching and learning activities through problem-based learning. The essential issues in this topic involve students' conceptual understanding of perimeter and area.

Additionally, according to Majid (Lestari et al., 2018), worksheets can facilitate teachers in preparing and conducting instruction, assist students in understanding the material, and support

them in carrying out written learning activities. This is consistent with the current study, which shows that a PBL-based digital worksheet not only provides learning guidance but also enhances students' engagement and understanding of triangle perimeter and area. Overall, the findings indicate that the developed digital worksheet is valid, practical, and effective in supporting mathematics learning. The results of this study are in agreement with several previous studies that highlight the positive impact of PBL-based and interactive worksheets on students' motivation, engagement, and conceptual understanding.

## CONCLUSION

Based on the above, the overall evaluation of the digital worksheet on the topic of triangle perimeter and area by the three validators was classified as very valid. This digital worksheet is expected to serve as one of the references for teachers in implementing the PBL model in teaching the area and perimeter of triangles, as well as a guideline for presenting relevant problem situations to assist students in understanding these concepts. The study contributes to the field of mathematics education by providing empirical evidence on the validity of a PBL-based digital worksheet, demonstrating how technology-enhanced instructional materials can support conceptual understanding, and offering a model that can be adapted for other geometric topics. Future research is recommended to conduct broader testing by considering the practicality and effectiveness of the product.

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