



Developing PBL-based worksheet to foster self-confidence and problem-solving skills in learning transformation geometry

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Abstract

This research aims to develop a valid and practical Problem-Based Learning (PBL) student worksheet to facilitate them fostering their self-confidence and problem-solving skills in learning transformation geometry. Using the ADDIE model, this research involved 20 ninth-grade students of a private junior high school in Yogyakarta to learn the concepts of reflection and rotation using the worksheet. The worksheet integrates PBL syntax, self-confidence descriptors, and Polya's problem-solving indicators. The validation by experts and teachers yielded an average score of 90.36% (very high), while the students' response on the worksheet practicality yielded an average scores of 90% (small group) and 88.75% (large group). The scores mark a very practical indicator of the worksheet. The existence this worksheet enriches the best practices of the efforts to foster self-confidence and problem-solving skills among students.

Keywords: PBL, problem-solving, self-confidence, transformation geometry, worksheet

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INTRODUCTION

Mathematics education in the modern era requires students to go beyond simply mastering basic concepts to developing critical competencies. This change is in line with the Merdeka Curriculum, the recent curriculum applied in the Indonesian schools, particularly through the Ministry of Education Regulation Number 12 of 2024, which specifically targets the mastery of 21st-century skills. This curriculum emphasizes the need for students to develop problem-solving, reasoning, and mathematical communication skills in various real-life contexts (Jufriadi et al., 2022). These competency standards affirm the need for students to be prepared to apply mathematics effectively to overcome real-world challenges.

The competency requirements of the Merdeka Curriculum are a response to global dynamics and the complexity of 21st-century challenges, which require students to be equipped with 4C skills (critical thinking, creativity, communication, and collaboration). These skills are essential for students to become independent individuals who are able to apply mathematics effectively in real-world contexts (Agmita et al., 2021). Therefore, innovative mathematics learning designs that focus on active student experiences are necessary to achieve competency standards and ensure that graduates are prepared to face contemporary challenges (Purna et al., 2021).

Abidin (2020) suggested that, based on the results of TIMSS 2015 and PISA 2012, children in Indonesia are very low in their ability to solve contextual problems in everyday life. Similar findings are also confirmed in a recent analysis, which states that Indonesian students' problem-solving skills are still low (Alivana & Masriyah, 2025). In other words, problem-solving skills among Indonesian students are not yet optimal. Meika et al. (2021) argue that problem-solving

skills are considered optimal if students succeed in identifying solutions through effective procedures and strategies.

At first, we began to interview the teachers and students as well as observed the mathematics learning at SMP Muhammadiyah 1 Kalasan, a private Islamic junior high school in Yogyakarta, Indonesia. We found that problem-solving skills were still low. To confirm this, a pre-test was conducted on ninth-grade students in class IX A at SMP Muhammadiyah 1 Kalasan, which revealed their problem-solving skills according to Polya's steps. The results of the analysis of 19 respondents are presented in Figure 1.

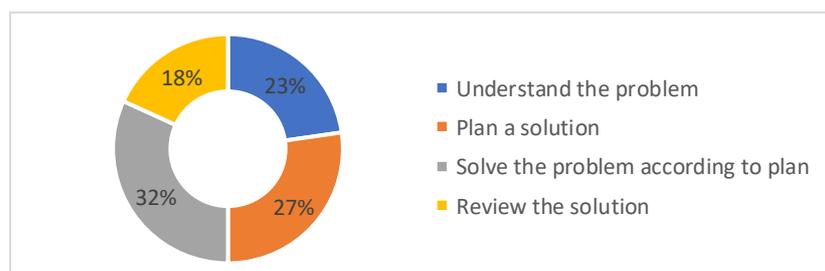


Figure 1. Pre-test analysis results.

Low problem-solving skills often stem from non-cognitive factors, in this case self-efficacy (self-confidence) is a fundamental factor. High self-confidence has been proven to be a strong predictor that encourages students to participate actively, persevere, and be academically resilient (Ananda & Wandini, 2022; Rahmah et al., 2024). Conversely, Jannah and Musfiroh (2024) argue that self-doubt causes students to tend to avoid difficulties and be reluctant to try. The results of the self-efficacy questionnaire for ninth-grade students were identified as low, with 16 respondents presented in Figure 2.

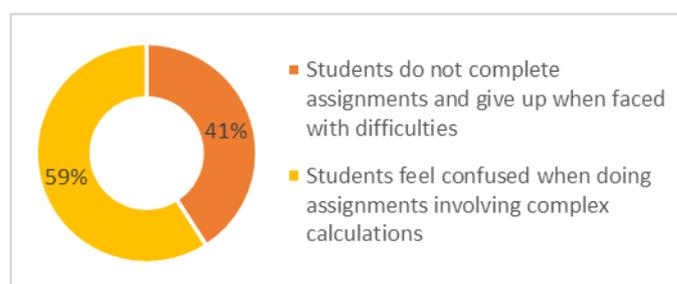


Figure 2. Students' confidence in mathematics lessons.

The implementation of an appropriate learning model is a key strategy for improving the quality and engagement of students. One highly relevant model is problem-based learning (PBL). This is a problem-oriented approach that encourages independent inquiry, solution development, and presentation of results (Ma'wa et al., 2021; Nisa' et al., 2023). Awalia (2023) argues that the problem-based learning model can be used to overcome a lack of problem-solving skills and self-confidence. It is because solving mathematical problems requires self-confidence. Students who believe in their abilities will find it easier to develop strategies.

However, observations and preliminary research data show that students' problem-solving skills and self-confidence are not yet optimal. Students' problem-solving skills do not emerge automatically. Until now, teachers have tended to only use textbooks from the library that contain non-routine exercises. Therefore, there is a need for media that teachers can use to guide students in problem solving in problem-based learning (Hasanah et al., 2021). One of the

tools that can develop students' problem-solving skills is the student worksheet (Rafianti et al., 2025). Several studies have stated that student worksheets are effective in increasing self-confidence through various approaches (Aeni et al., 2025; Utami, 2020).

In line with these findings, the ninth-grade mathematics teacher also suggested a solution through the use of printed worksheets. Based on the results of the teacher needs survey, it was identified that students had difficulties with the material on reflection and rotation. This is in line with the pre-research data showing that students had difficulties with the material on reflection (36.5%) and rotation (26.9%). These difficulties arose because the material was presented in a monotonous manner (based on formulas), which did not facilitate visualization and exploration.

Therefore, this study focuses on the development of problem-based learning-based worksheets specifically designed to guide visualization and problem solving. Although there have been many studies on the application of problem-based learning and the development of worksheet, to date there have been no studies that specifically integrate worksheet based on problem-based learning for geometric transformation material (reflection and rotation) while explicitly targeting the improvement of problem-solving skills and self-efficacy.

Based on the urgency of the problem and the potential solutions offered, this development research aims to: (1) produce a valid and practical student worksheet based on Problem Based Learning on the material of reflection and rotation, and (2) describe how the product can facilitate students' self-confidence and problem-solving skills. Until this research was conducted, the development of worksheet based on Problem Based Learning on reflection and rotation material had never been done, so this research is expected to fill this gap. The results of this study are expected to provide practical contributions in the form of innovative teaching materials for educators, as well as theoretical contributions regarding the role of integrating PBL in worksheet to overcome cognitive and affective barriers in mathematics learning.

RESEARCH METHOD

The type of this research is Research and Development (R&D) which aims to produce valid and practical learning products. The development model used is ADDIE (Analysis, Design, Development, Implementation, Evaluation), which was chosen because this framework is systematic and iterative, allowing researchers to identify needs in depth before designing products, as well as conducting continuous evaluations at each stage (Ranuharja et al., 2021).

The subjects in this study were 20 ninth-grade students at SMP Muhammadiyah 1 Kalasan. The subjects were selected using purposive sampling with the criteria of students who had access to the developed learning tools and were at a homogeneous academic ability level. A sample of 20 students was selected because it represented an entire class available at the time of the limited trial, which was the initial stage of product validation in R&D research (Sugiyono, 2019). In line with the design and subjects, the development research flow using the ADDIE model in this study is presented in Figure 3.

The data collection methods used in this study included interviews, written tests, and questionnaires. This development study aims to produce a product that has been tested for validity and practicality. The validity of the learning media, which includes aspects of format, content, and language (Saniriati et al., 2021), was obtained from the results of validation by two lecturers from the Mathematics Education Department, Universitas Ahmad Dahlan, and one mathematics teacher from the school where the research was conducted.

$$NA = \frac{S}{SM} \times 100\% \quad (1)$$

NA : Final score

S : Score obtained

SM : Maximum score

The data from the media validation sheets were analyzed by calculating the average score and determining the category (Novaliendry et al., 2021). The Equation (1) is the formula used to calculate the validity score.

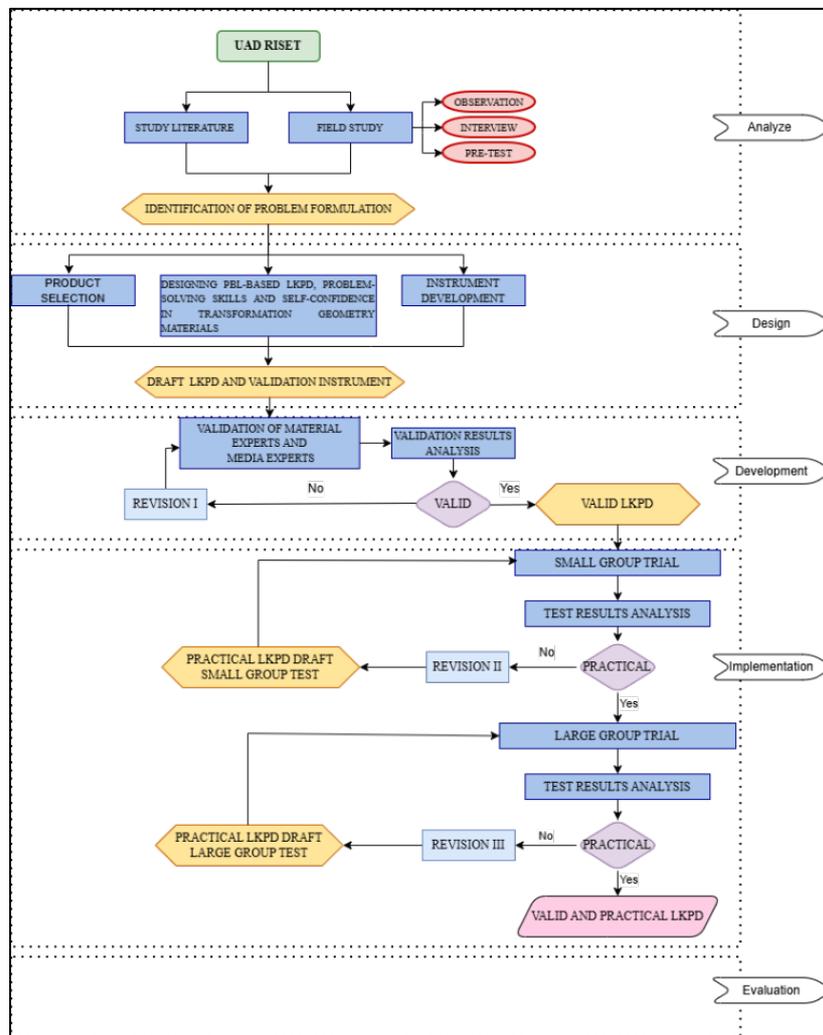


Figure 3. Steps of ADDIE research.

The worksheet can be considered valid if the validation results show an interpretation of “high” or “very high” in Table 1.

Table 1. Worksheet validation score criteria

Value Criteria	Category
$80 < NA \leq 100$	Very high
$60 < NA \leq 80$	High
$40 < NA \leq 60$	Fair
$20 < NA \leq 40$	Less
$0 < NA \leq 20$	Invalid

Source: Modified from Riduwan (2010).

After media validation, trials were conducted in learning activities. The data obtained from student responses was then calculated to find the average score using the formula of Equation (1), while the practicality criteria is presented in Table 2.

Table 2. Worksheet practicality score criteria

Value Criteria	Category
$80 < NA \leq 100$	Very Practical
$60 < NA \leq 80$	Practical
$40 < NA \leq 60$	Not Practical Enough
$20 < NA \leq 40$	Less Practical
$0 < NA \leq 20$	Impractical

Source: Modified from Riduwan (2010).

RESULTS AND DISCUSSION

The results of this development research are (1) a mathematics student worksheet based on problem-based learning to facilitate students' confidence and problem-solving skills in printed form, (2) assessment by subject matter experts, media experts, and teachers of the mathematics worksheet that has been created, (3) student perceptions of the use of the worksheet obtained from a questionnaire and validated by instrument experts. The use of this worksheet employs the ADDIE development model with the following steps: (1) analyze, (2) design, (3) development, (4) implementation, and (5) evaluation.

Analysis

During the analyze stage, several stages were carried out, namely observation, which revealed that during the teaching and learning process in the classroom, students were reluctant to answer questions asked by the teacher. When working on the questions given by the teacher, the researcher observed that students did not immediately collect them but instead relied on their friends' answers as a form of confirmation that the answers produced were the same. Students also became confused when they encountered questions that were different from the examples given by the teacher. Students would immediately ask the teacher how to solve the problem without trying to solve it themselves first. This indicates low self-confidence and problem-solving skills among students. This finding was reinforced by the results of interviews with teachers, who stated that most students immediately refused when asked to solve problems on the blackboard or when asked to answer questions from the teacher. Based on the results of the interviews, the teachers also said that students had difficulty understanding different types of questions. The assessment of problem-solving skills was also validated through an analysis of the pre-test answers. The evidence found in the field is presented in Figure 4.

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① Jumlah dari $4x + 5y - 8z$ dan $x - 2y - 3z$ adalah :

A. $5x + 3y - 11z$ C. $5x - 3y - 11z$
 B. $4x + 3y - 11z$ D. $4x - 3y - 11z$

Jawab :

$$= 4x + 5y - 8z + x - 2y - 3z$$

$$= (4x + x) + (5y - 2y) + (8z + 3z)$$

$$= (5x) + (3y) + (11z)$$

$$= 5x + 3y - 11z$$

(A)

Figure 4. Student's work.

Furthermore, the work plan that has been designed includes creating a storyboard and teaching material designs in the form of student worksheets, compiling implementation or development objectives, producing testing strategies, validating teaching materials by subject matter experts and media experts, and conducting small group trials and large group trials.

Design

This design stage aims to produce a preliminary design for the worksheet. Researchers integrated the syntax of problem-based learning, self-confidence dimensions, and problem-solving ability indicators into the structure of the worksheet reflection and rotation materials. The design process included two main aspects, namely visual design and didactic content development. Visually, the researcher designed the layout, cover, and selected attractive color compositions to support the visualization of the reflection and rotation materials. In terms of content, the researcher compiled a systematic structure that included learning objectives, instructions for use, and student learning activities. The steps of the activities in the worksheets were systematically constructed following the syntax of problem-based learning to stimulate problem-solving skills and build students' confidence.

Development

At this stage, a flowchart and storyboard are created, and a problem-based learning-based worksheet is developed. For the problem-based learning-based worksheet product for grade IX, the reflection and rotation material can facilitate self-confidence and problem-solving skills. There is an activity sheet in the worksheet that discusses using problem-based learning syntax. One of the integrated steps in the problem-based learning worksheet to facilitate students' self-confidence and problem-solving skills is shown in Figure 5.

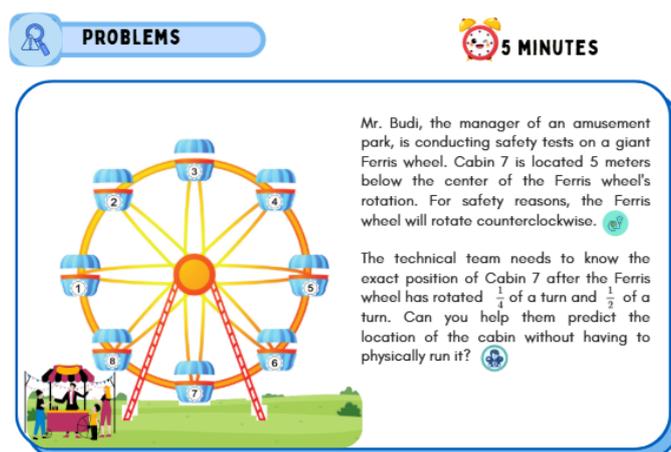


Figure 5. One of the steps in completing the worksheet.

Figure 5 is one part of the worksheet that has been designed as a solution. This worksheet specifically integrates the syntax of problem-based learning as the main learning model, along with the dimensions of self-confidence and problem-solving ability indicators as supporting variables that are measured. This design ensures that learning activities are not only focused on the material, but also on the development of students' metacognitive and affective skills.

This worksheet is designed in accordance with the syntax of problem-based learning as a whole, which forms the basis for each stage of the process. The stages of problem-based learning consist of five main steps, which are presented as a flow of learning activities for students. These steps include: an orientation stage where students are given a problem; then forming groups; next, investigating and guiding individuals or study groups; followed by presenting the results of their work; and finally evaluating the process of the problem that has been solved. One of the syntaxes of problem-based learning in the worksheet can be seen in Figure 6a. The figure presents the first syntax of problem-based learning, namely the orientation stage for students on the problem, where students are given contextual and challenging problems that will be the main focus of their learning.

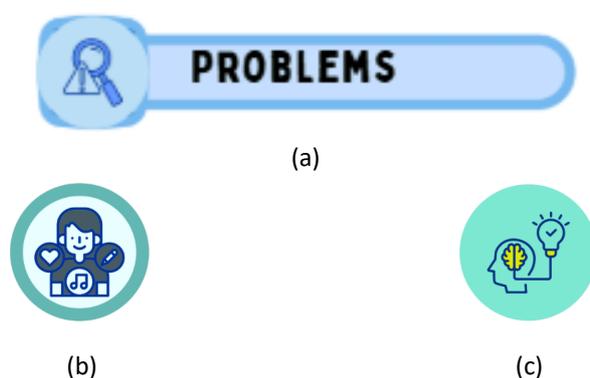


Figure 6. The PBL syntax is available under this sign (a); symbols of self-confidence in the worksheet (b); symbols indicating problem-solving skills in the worksheet (c).

In addition to the syntax of problem-based learning, the worksheet is designed to include three dimensions of student confidence as supporting variables. These three dimensions are further broken down into six descriptions of student behavior that are expected to emerge during the learning process. These descriptions include: (1) having an interest in completing tasks, (2) being optimistic about being able to complete tasks, (3) being confident about one's abilities, (4) being persistent and never giving up, (5) being confident that problems can be solved regardless of specific conditions or situations, and (6) having a positive attitude when dealing with problems. To measure and facilitate the development of attitude aspects in students, one of the symbols of self-confidence observed in the worksheet is presented in Figure 6b. This symbol specifically describes the first indicator of self-confidence, namely having an interest in completing the tasks and challenges given.

Other supporting variables integrated into the worksheet are four problem-solving ability indicators that must be achieved by students. These indicators serve as guidelines in the problem-solving stages contained in each worksheet, in line with the PBL steps. The four problem-solving ability indicators in the worksheet consist of: understanding the problem, planning the solution, solving the problem according to the plan, and reviewing the solution that has been implemented. One of the symbols for problem-solving ability indicators in the worksheet is shown in Figure 6c. This symbol reflects the first problem-solving ability indicator, which is understanding the problem. At this stage, students are directed to identify known and unknown data and analyze the adequacy of the available information as a basis for planning solutions.

The worksheet that has been developed contains the entire syntax of problem-based learning as the main step in the solution. The consistency of the design is reinforced by the inclusion of all symbols describing self-confidence and all symbols indicating problem-solving skills, where these three main components are presented in full in each unit of reflection and rotation material. With this comprehensive integration, the worksheet not only functions as a guide to problem solving, but also facilitates the cognitive, metacognitive, and affective development of students.

Next, there are the results of material validation by subject matter experts on worksheet based on problem-based learning to facilitate confidence and problem-solving skills in the reflection and rotation materials that have been created by filling out an open assessment questionnaire consisting of 6 indicators with 30 questions. The results of the material validation contained in each statement provided by the material experts gave a very good and appropriate response to the overall revised worksheet material in the form of improvements in the

assessment. Next, the results of the learning media validation by media experts on the problem-based learning-based worksheet to facilitate confidence and problem-solving skills in the reflection and rotation materials that had been created by filling out an open assessment questionnaire consisting of 3 indicators with 21 questions. At this stage, the worksheet was revised based on suggestions provided by the material validators and media validators. The suggestions received were in the form of written and verbal suggestions.

In addition to providing qualitative input, validators also provide quantitative assessments through validation sheets. The assessment covers aspects of material feasibility that support problem-solving skills and design aspects that facilitate student confidence. Based on the calculation results, the average validity score is obtained as shown in the Table 3.

Table 3. Validation analysis results

Experts and Supervising Teachers	Average
Subject Matter Experts	87.33%
Media Experts	84.76%
Supervising Teachers	99%
Average Percentage (%)	90.36%

Based on the table above, the average total validation score reached 90.36% with the category “very high.” Thus, the PBL-based worksheet to facilitate self-confidence and problem-solving skills is declared feasible to be tested at the implementation stage.

Implementation

At the implementation stage, after the worksheet was revised in accordance with the suggestions and comments of the expert team, the practicality of the product was tested through two stages of trials, namely a small group test and a large group test.

Small group testing

A small group trial was conducted with non-research subjects. This trial was conducted in class IX-A of SMP Muhammadiyah 1 Kalasan with five students with low, medium, and high abilities, as determined based on information from the mathematics teacher who taught the class. Each student was given a printed version of the worksheet developed by the researcher. This product trial lasted for one lesson hour, providing an overview of the material and student activities in the worksheet. Next, students were asked to observe the worksheet thoroughly and provide an assessment in the form of their responses to the developed worksheet by filling out a questionnaire. The questionnaire for this small group trial contained a grid with 4 indicators and 12 questions. Based on the students' responses, it can be concluded that the small group trials conducted by S1, S2, S3, S4, and S5 provided comments that the learning instructions should be shortened to make them easier to understand. Based on the responses of the small group test participants, it can be generally concluded that they are interested in learning using problem-based learning worksheets to facilitate self-confidence and problem-solving skills. The worksheets developed are good for use as learning resources, and the language used in the worksheets is easy to understand.

Large group testing

After the small group trial and the worksheet had been revised, a large group trial was conducted. This trial involved 20 students in class IXA at SMP Muhammadiyah 1 Kalasan. The trial lasted for approximately 2 hours of lessons. After all participants in the large group trial observed the printed worksheets prepared by the researcher, they were asked to provide feedback on the worksheets used. The students' feedback was obtained from a questionnaire to determine their responses to the worksheets developed. Based on the students' responses,

it can be concluded that out of the 20 respondents who filled out the questionnaire, there were positive responses. They were interested in using the problem-based learning-based worksheet because they felt more confident in working on and acquiring structured problem-solving skills. The following are the findings from the student response questionnaire in the Table 4.

Table 4. Practicality analysis results

Test Subjects	Response Results	Description
Small Group Testing	90%	Very Practical
Large Group Testing/Field Testing	88,75%	Very Practical

Based on the results of the student response questionnaire analysis, it was found that the worksheet was in the “very practical” category. The high practicality score indicates that the problem-based learning-based worksheet to facilitate self-confidence and problem-solving skills is easy to use, the flow of activities is easy to understand, and it can facilitate the teaching and learning process.

Evaluation

At this evaluation stage, researchers evaluated the worksheet from the analyze stage to the implementation stage. This was done to determine whether the learning activities carried out using the worksheet could facilitate students in exploring and whether it could provide new experiences for students' learning in the classroom. In addition, the strengths and weaknesses of the worksheet can also be identified after the researchers conduct the research process or test the product on ninth-grade students at SMP Muhammadiyah 1 Kalasan.

Discussion

The use of problem-based learning-based worksheet developed by the researcher has been proven to be valid and practical in facilitating students' self-confidence and problem-solving skills. The results of validation by subject matter experts and media experts were (87.33%) and (84.76%), respectively. The results of the small group product trial (90%) and the large group product trial (88.75%) were obtained. The results of this study are in line with several other studies, including one conducted by (Meha et al., 2025) entitled Developing student worksheet based on Problem-Based Learning (PBL) to improve students' learning outcomes. Based on the results of the research on the developed worksheet, the average results for all aspects obtained from the research subjects were 90.48% for the small group product use trial and 91.56% for the large group product trial. With these results, it can be concluded that this problem-based learning-based worksheet is suitable for use.

The contribution of this research to science is that it can be used as a learning resource for teachers and students in learning reflection and rotation materials that facilitate students' self-confidence and problem-solving skills. It can also be used as a reference for students in completing their final assignments, especially in developing worksheet based on cognitive (problem-solving skills) and affective (self-confidence) abilities.

CONCLUSION

The development of worksheet based on Problem Based Learning (PBL) in mathematics lessons on reflection and rotation was successfully carried out using the ADDIE development model, which was proven to be valid based on the validator's assessment and practical based on the responses of teachers and student activities. However, this study has several limitations, in which the development is limited to the reflection and rotation material for grade IX, the trial was only conducted at SMP Muhammadiyah 1 Kalasan so that the generalization of the results is limited, and the long-term impact on learning outcomes has not been measured. In line with this, teachers are advised to implement this worksheet as alternative teaching material, while

other researchers are advised to conduct further research by developing worksheet on other mathematics materials, expanding the sample to various types of schools, and integrating digital technology to improve the quality of learning products in the future.

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DECLARATION

Author contribution

All authors contribute in the research and/or writing the paper, and approved the final manuscript.

Santi Conceptualizing the research idea, leading the investigation, setting up the methodology, analyzing the data, and writing the original draft.

Burhanudin Arif Nurnugroho Assisting the investigation, reviewing the validity of the methodology, and supervising the data analysis.

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Conflict of interest

All authors declare that they have no competing interests.

Ethics declaration

We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Education Insight (IJEI) in maintaining the high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

The use of artificial intelligence

We do not use any generative AI tools to write any part of this paper.

Additional information

Not available.

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