



## Development of problem solving-based student worksheets (LKPD) to improve mathematical problem-solving abilities and self-efficacy of junior high school students

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### Abstract

**Background:** Mathematical problem-solving ability and self-efficacy are important components in mathematics learning because they influence students' capacity to understand problems, apply strategies, and persist in solving challenging tasks. However, many students still experience difficulties in solving contextual mathematical problems, indicating the need for instructional materials that support both cognitive and affective aspects of learning.

**Aims:** This study aims to develop problem-solving-based student worksheets (LKPD) integrated with a contextual sports game setting for learning the Pythagorean Theorem and to evaluate their validity, practicality, and effectiveness in improving students' mathematical problem-solving ability and mathematics self-efficacy.

**Method:** This study employed a research and development approach using the ADDIE model. The effectiveness of the developed worksheet was examined through a quasi-experimental design involving an experimental group and a control group. Data were collected using expert validation sheets, practicality questionnaires, problem-solving ability tests, and self-efficacy questionnaires, and analyzed using descriptive statistics and independent samples t-tests.

**Results:** The validation results indicated that the worksheet was highly valid (89.5%), while the practicality test showed that it was very practical (89.67%). The effectiveness analysis revealed a significant difference between the experimental and control groups in both mathematical problem-solving ability ( $t(55) = -6.021, p < .001$ ) and mathematics self-efficacy ( $t(55) = -2.648, p = .011$ ).

**Conclusion:** The problem-solving-based LKPD with a contextual sports setting is valid, practical, and effective for improving students' mathematical problem-solving ability and self-efficacy in learning the Pythagorean Theorem.

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## INTRODUCTION

Mathematical problem-solving ability is widely recognized as one of the most essential competencies in mathematics education because it reflects students' capacity to interpret situations, formulate strategies, and apply mathematical concepts in various contexts. In contemporary mathematics education, problem solving is not only considered a learning objective but also a fundamental process through which students develop higher-order thinking skills. Scholars emphasize that the ability to solve mathematical problems supports students in constructing conceptual understanding and applying knowledge flexibly in unfamiliar situations (Hong et al., 2023; Szabo et al., 2020). Moreover, problem-solving ability is closely associated with the development of reasoning and critical thinking skills required in twenty-first century learning environments (Häkkinen et al., 2017; Iñiguez-Berrozpe & Boeren, 2020). Research also indicates that students who actively engage in problem-solving activities tend to demonstrate deeper conceptual

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understanding and improved learning outcomes in mathematics (Ncube & Luneta, n.d.; Sinaga et al., 2023). Despite its importance, many students still encounter difficulties when dealing with non-routine and contextual mathematical problems that require interpretation and modeling of real-life situations (Evans et al., 2021). These challenges suggest that strengthening students' problem-solving abilities remains a critical issue in mathematics education. Therefore, mathematics instruction needs to provide effective learning strategies and resources that support students in developing systematic and meaningful problem-solving skills.

One approach that has been widely implemented to support the development of students' problem-solving abilities is the use of structured instructional materials, particularly student worksheets. Student worksheets are considered effective learning tools because they guide students through a sequence of learning activities and encourage active engagement in constructing mathematical understanding. Well-designed worksheets can help students organize their thinking processes, explore various strategies, and gradually develop conceptual knowledge through guided tasks (Fadillah et al., 2025). Several studies have shown that worksheets integrated with contextual learning approaches can improve students' mathematical reasoning and problem-solving abilities (Basid et al., 2024; Sari et al., 2022). In addition, worksheets designed based on problem-solving principles allow students to practice identifying problems, planning strategies, implementing solutions, and evaluating results systematically (Widodo et al., 2023; Yanto, 2019). The integration of real-life contexts in worksheets also enables students to connect abstract mathematical concepts with meaningful experiences encountered in everyday life (Gainsburg, 2008a; Yanto, 2019). As a result, contextual worksheets can make mathematics learning more meaningful and engaging for students. Consequently, the development of problem-solving-based worksheets has become an important focus in efforts to improve the quality of mathematics instruction.

Although instructional materials such as worksheets can support students' cognitive development, mathematics learning is also strongly influenced by affective factors. One of the most important affective factors in mathematics education is students' mathematics self-efficacy. Self-efficacy refers to students' beliefs in their capability to successfully perform mathematical tasks and overcome learning challenges in specific situations (Musdi et al., 2024; Pajares, 1996). In the context of mathematics learning, students with high self-efficacy tend to demonstrate greater persistence, confidence, and willingness to engage in complex problem-solving activities (Kohen et al., 2022). Previous studies also show that students' self-efficacy is significantly related to their mathematical achievement and problem-solving performance (Öztürk et al., 2024). Students who believe in their abilities are more likely to explore different strategies and persist when facing challenging mathematical problems. In contrast, students with low self-efficacy often avoid difficult tasks and experience higher levels of anxiety when learning mathematics. Therefore, mathematics learning should not only aim to improve cognitive abilities but also foster students' confidence and positive beliefs about their mathematical competence (Kohen et al., 2022; Öztürk et al., 2024).

Several previous studies have shown that the use of learning tools or worksheets can improve students' mathematical problem-solving abilities. For instance, ethnomathematics-based worksheets have been reported to positively influence students' problem-solving skills by integrating contextual and cultural elements into mathematics learning (Wahyuni et al., 2025). Similarly, the development of learning tools based on Problem-Based Learning (PBL) has been found to effectively enhance students' mathematical problem-solving performance (Musdi et al., 2024). In addition, the integration of visual supports within mathematical worksheets has also been shown to help students better interpret and solve mathematical word problems (Şahinkaya et al., 2024). These findings indicate that well-designed instructional materials, particularly worksheets, can play an important role in facilitating students' mathematical thinking and problem-solving processes.

However, most of these studies mainly emphasize cognitive outcomes, particularly the improvement of students' problem-solving skills. Limited attention has been given to affective aspects of mathematics learning, especially students' mathematics self-efficacy, which is considered an important factor influencing students' persistence, engagement, and performance in solving mathematical problems (Kohen et al., 2022; Öztürk et al., 2024). Previous studies examining self-efficacy in mathematics often focus on technology-based or digital learning environments, such as applet-based exploratory teaching, which has been shown to improve students' mathematics self-efficacy (Freitas et al., 2025). Nevertheless, research that simultaneously integrates worksheet-based problem-solving activities with the development of students' mathematics self-efficacy remains limited.

Therefore, there is a need for instructional materials that not only support the development of mathematical problem-solving abilities but also foster students' mathematics self-efficacy in an integrated manner. In response to this gap, the present study aims to develop and evaluate problem-solving-based student worksheets (LKPD) integrated with a contextual sports game setting for learning the Pythagorean Theorem. Specifically, this study seeks to examine the validity and practicality of the developed worksheet, as well as its effectiveness in improving students' mathematical problem-solving abilities and mathematics self-efficacy among Grade VIII junior high school students.

## METHOD

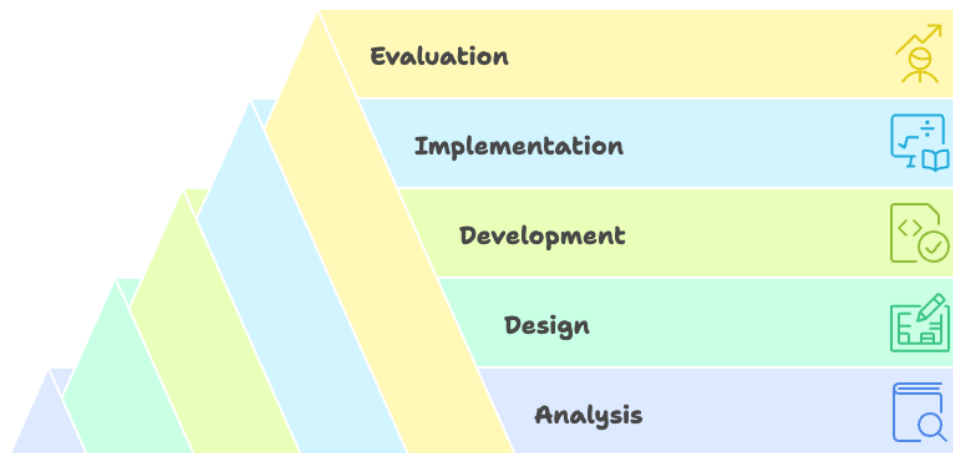
### Research Design

This research uses a research and development approach with the aim of producing a product in the form of a Student Worksheet (LKPD) and examining the quality and effectiveness of its use in mathematics learning. The product development process follows the ADDIE model which includes the stages of analysis, design, development, implementation, and evaluation. This model is used with consideration of its systematic flow and its relevance in the development of educational teaching materials (Gainsburg, 2008a). The connection between real experience and mathematical concepts is expected to help students build a more meaningful and contextual understanding (Boaler, 1993; Gainsburg, 2008b). In addition, a familiar context allows students to relate mathematical problems to daily activities, thus supporting the process of constructing understanding and applying concepts in problem solving (Almuna Salgado, 2017).

The design stage is focused on the preparation of the LKPD design which contains a series of problem-solving activities in the context of sports games. The activity is designed to guide students in understanding problems, formulating solution strategies, and applying mathematical concepts contextually (Basid et al., 2024). The design of the LKPD is adjusted to basic competencies, competency achievement indicators, and junior high school learning objectives to be in harmony with the demands of the curriculum and the characteristics of students' cognitive development (Sugianto et al., 2022). At this stage, the principle of meaningful learning becomes the main concern, especially using contexts that are close to students' experiences so that it can increase learning engagement and strengthen the understanding of mathematical concepts (Bray & Tangney, 2016; Mulqueeny et al., 2015; Polman et al., 2021).

The development phase began with expert validation of the developed student worksheet (LKPD) to evaluate its quality in terms of content, language, presentation, and graphics/layout. (Fariz et al., 2025). LKPD that has been declared valid is then tested to students to obtain information about practicality, including ease of use, readability, and implementation in learning (Wedana et al., 2025). The implementation of LKPD was carried out in the experimental class, while the control class followed conventional mathematics learning without using the developed LKPD (Hidayat & Aripin, 2023; Noviyana & Ab, 2025). The next evaluation stage is directed to assess the effectiveness of LKPD

based on students' achievements in mathematical problem-solving skills and self-efficacy. The design flow for developing LKPD in this study can be seen in Figure 1.



**Figure 1.** Developing and Evaluating Student Worksheets

The effectiveness of LKPD testing was carried out using a quasi-experiment design involving the experimental group and the control group. This design was chosen because of the limitations of the researcher in randomizing the subjects in full, but it still allowed us to compare the effects of treatment on two groups that had relatively equivalent characteristics. In the experimental class, learning is carried out using the developed LKPD, while the control class follows mathematics learning as usually applied by teachers. The research design used is presented in Table 1.

**Table 1.** Research Design

Groups	Treatment	Posttest
Experimental Class	Learning using LKPD based on problem solving	$O_1$
Control Class	Conventional learning	$O_2$

### Participants

The subject of the study was grading VIII students of SMP Al Irsyad Al Islamiyah Purwokerto which consisted of two classes, namely an experimental class of 32 students and a control class of 25 students. The determination of the subjects of the experimental class and the control class was carried out by considering the equality of students' initial abilities based on the results of the initial evaluation and the recommendations of the mathematics subject teacher.

To ensure baseline equivalence, students' mid-semester mathematics examination scores were reviewed prior to the intervention. The average scores of the experimental and control classes were relatively comparable, indicating no meaningful difference in prior mathematical achievement. In addition, the mathematics teacher confirmed that both classes demonstrated similar academic performance and learning characteristics before the study commenced. Overall, these considerations suggest that the two groups were reasonably comparable at baseline.

The experimental class obtained learning using the developed LKPD, while the control class followed the usual mathematics learning without using the LKPD.

### Instrument

The research instruments include expert validation sheets, practicality questionnaires, mathematical problem-solving ability tests, and self-efficacy questionnaires. The validation sheet is used to assess the feasibility of LKPD from the aspects of content, presentation, language, and graphics. The practicality questionnaire is used to find out the ease of use of LKPD by students. The mathematical problem-solving ability test is designed to measure students' ability to understand

problems, design strategies, implement solutions, and re-examine the results of the solution. The self-efficacy questionnaire is used to measure students' confidence in their ability to complete math tasks.

The mathematical problem-solving test was developed based on Polya's four stages of problem-solving. Content validity was established using the Content Validity Ratio (CVR) through expert evaluation, and all items met the required validity threshold, indicating strong alignment with the intended construct. Reliability analysis using Cronbach's alpha yielded a coefficient of 0.828, demonstrating good internal consistency. These findings indicate that the instrument is both valid and reliable for measuring students' mathematical problem-solving ability.

Students' self-efficacy in mathematical problem-solving was measured using a 35-item questionnaire developed based on Bandura's (1997) theoretical framework, encompassing three dimensions: magnitude, strength, and generality. The instrument consisted of both positively and negatively worded statements to reduce response bias. Responses were recorded using a four-point Likert scale ranging from 1 to 4, with the following anchors: 1 = Never (TP), 2 = Rarely (J), 3 = Often (SR), and 4 = Always (SL) for positively worded items, and reverse scoring applied for negatively worded items.

Content validity was established using the Content Validity Ratio (CVR) based on expert evaluation. All items met the minimum CVR threshold, indicating adequate content relevance and representativeness of the construct. Reliability analysis using Cronbach's alpha yielded a coefficient of 0.832, demonstrating strong internal consistency.

### Data Analysis

The data were analyzed using both descriptive and inferential statistical techniques. Descriptive statistics were calculated to summarize the mean, standard deviation, and distribution characteristics of each variable. Prior to hypothesis testing, statistical assumptions were examined, including normality (Shapiro-Wilk test) and homogeneity of variance (Russell et al., 2022).

If the assumptions of normality and homogeneity were satisfied, independent samples t-tests were conducted to compare mathematical problem-solving ability and self-efficacy between the experimental and control groups. In addition to reporting p-values, effect sizes were calculated using Cohen's d to determine the magnitude of group differences, and 95% confidence intervals were reported to provide estimation precision. In cases where normality assumptions were violated, a non-parametric Mann-Whitney U test was employed as a robustness check. Outliers were examined using standardized residuals and boxplot inspection to ensure that extreme values did not unduly influence the results. This analytical approach ensures that statistical conclusions are both meaningful and methodologically defensible (Hannigan & Lynch, 2013).

### 1. Validity Analysis

The LKPD was validated by three experts. In the first stage, the feasibility level from each validator was calculated using a percentage formula, defined as the ratio of the obtained score to the maximum possible score multiplied by 100%. LKPD validity data was analyzed using percentage criteria with reference values as presented in Table 2.

**Table 2.** Validity Criteria

Percentage	Category
81%–100%	Highly Valid
61%–80%	Valid
41%–60%	Quite Valid
21%–40%	Less Valid
0%–20%	Invalid

To strengthen item-level content validity, the evaluations from all three validators were further analyzed using the Content Validity Ratio (CVR) proposed by Lawshe (1975), calculated as follows:

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}}$$

Where:

$n_e$  = number of experts indicating the item as essential

$N$  = total number of experts

## 2. Practicality Analysis

The practicality of LKPD was analyzed based on the results of the student response questionnaire using the criteria in Table 3.

**Table 3.** Practical Criteria

Percentage	Categories
81%-100%	Very Practical
61%-80%	Practical
41%-60%	Quite Practical
21%-40%	Less Practical
0%-20%	Impractical

## 3. Effectiveness Analysis

Before the hypothesis test, the data was tested prerequisites, including the normality test using the Shapiro-Wilk test and the homogeneity test using the Levene test. After the prerequisites were met, a t-test was performed on two independent samples to determine the difference in mathematical problem-solving ability and self-efficacy between the experimental class and the control class at a significance level of 0.05.

## RESULTS AND DISCUSSION

### Results

#### 1. Description of the Developed Worksheet

The student worksheet (LKPD) developed in this study was designed to facilitate students' mathematical problem-solving ability in learning the Pythagorean Theorem through contextual situations related to sports activities. The worksheet integrates real-life contexts to help students connect abstract mathematical concepts with meaningful learning experiences. The structure of the worksheet follows several stages of mathematical problem solving, including understanding the problem, planning a solution strategy, implementing the solution, and verifying the results. Each section of the worksheet contains guiding questions intended to support students in constructing their own mathematical reasoning and solution strategies.

The contextual problems presented in the worksheet encourage students to analyze situations, identify relevant mathematical relationships, and apply the Pythagorean Theorem to solve problems systematically. By incorporating contextual learning activities, the worksheet aims to enhance both students' conceptual understanding and their engagement during the learning process. An example of the developed problem-solving-based worksheet used in this study is presented in Figure 2.



Figure 2. Example of the problem-solving-based worksheet developed in this study

2. LKPD Validation Result by Expert

The LKPD validation was carried out by three experts to assess the feasibility of the product in terms of content, language, presentation, and graphics. Based on Table 4., the LKPD developed is in the category of being very valid and suitable for use in learning after revision according to the validator's suggestion.

Table 4. LKPD Validation Results by Experts

Validator	Acquisition Score	Maximum Score	Prosentase	Categories
Validator 1	153	176	86,9%	Highly Valid
Validator 2	157	176	89,2%	Highly Valid
Validator 3	163	176	92,6%	Highly Valid
Average Score	157,67	176	89,5%	Highly Valid

The CVR results = 1, Therefore, the CVR analysis reinforced the percentage-based validation results, confirming that the developed LKPD met the required content validity standards.

3. LKPD Practicality Test Result

The practicality test in this study was conducted as a limited pilot involving ten students to obtain preliminary insights into the usability, readability, and implementation feasibility of the LKPD. While the sample size was small, the practicality findings were further supported through classroom observations and teacher feedback, providing additional evidence for the feasibility of the developed worksheet. The results of the practicality test are presented in Table 5.

**Table 5.** LKPD Practicality Test Results

Responden	Acquisition Score	Maximum Score
Student 1	55	60
Student 2	54	60
Student 3	55	60
Student 4	50	60
Student 5	55	60
Student 6	55	60
Student 7	54	60
Student 8	50	60
Student 9	55	60
Student 10	55	60
Average	53,8	60
Percentage	89,67%	
Category	Very Practical	

#### 4. LKPD Effectiveness Test Result

##### a) Results of Problem-Solving Ability Analysis

Before the hypothesis test, a prerequisite test was carried out, namely the normality and homogeneity test, the results of which are presented in Table 6. The normality test of cognitive value data was carried out using the Shapiro–Wilk test because the number of samples in each class was less than 50. The variance homogeneity test was carried out using the Levene Test.

**Table 6.** Normality Test Results of Problem-Solving Ability

Tests of Normality						
	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Kontrol	.123	25	.200 <sup>*</sup>	.956	25	.344
Eksperimen	.158	25	.109	.920	25	.051

\*. This is a lower bound of the true significance.  
a. Lilliefors Significance Correction

The results of the normality test showed that the value data in the control class had a significant value of 0.344, while in the experimental class it was 0.051. The significant value of the two classes is greater than 0.05, so it can be concluded that the value data in the control class and the experimental class are normally distributed.

**Table 7.** Homogeneity Test Results of Problem-Solving Ability

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
nilai	Based on Mean	3.014	1	55	.088
	Based on Median	2.841	1	55	.098
	Based on Median and with adjusted df	2.841	1	39.765	.100
	Based on trimmed mean	2.730	1	55	.104

The test results showed a significant value of 0.088. Since the significance value is greater than 0.05, it can be concluded that the variance of cognitive value data between the control class and the experimental class is homogeneous. Thus, the data are eligible for parametric statistical tests.

Based on the results of the normality and homogeneity tests, an independent samples t-test assuming equal variances was conducted to examine differences in mathematical problem-solving ability between the experimental and control groups. The analysis revealed a statistically significant difference between the two groups,  $t(55) = -6.021$ ,  $p < .001$ . Thus, it can be concluded that students in the experimental and control groups differed significantly in their mathematical problem-solving ability.

**Table 8.** T-test Results of Problem-Solving Ability

		Independent Samples Test								
		Levene's Test for Equality of Variances			t-test for Equality of Means				95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
nilai	Equal variances assumed	3.014	.088	-6.021	55	.000	-22.074	3.666	-29.421	-14.726
	Equal variances not assumed			-5.670	36.850	.000	-22.074	3.893	-29.964	-14.184

An independent samples t-test assuming equal variances revealed a statistically significant difference between the experimental and control groups,  $t(55) = -6.021$ ,  $p < .001$ . The experimental group obtained a higher mean score ( $M = 83.61$ ) compared to the control group ( $M = 61.51$ ). The mean difference, computed as Experimental – Control, was  $-22.074$  with a 95% confidence interval of  $[-29.421, -14.726]$ . The magnitude of the difference was very large (Cohen's  $d = 1.61$ ). These findings indicate a substantial difference in cognitive performance on the Pythagorean Theorem material between students who learned using the problem-solving-based LKPD with a sports context and those who received conventional instruction.

a) Results of Self-Efficacy Analysis

Normality was assessed using the Shapiro–Wilk test. The control group showed  $W = .956$ ,  $p = .344$ , while the experimental group showed  $W = .920$ ,  $p = .051$ . Although the experimental group's p-value was borderline, both values exceeded the .05 significance level, indicating that the assumption of normality was met.

**Table 9.** Normality Test Results of Self-Efficacy

Tests of Normality						
	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Kontrol	.123	25	.200*	.956	25	.344
Eksperimen	.158	25	.109	.920	25	.051

\*. This is a lower bound of the true significance.  
a. Lilliefors Significance Correction

Homogeneity of variance was examined using Levene's test, which yielded  $F(1,55) = .246$ ,  $p = .622$ , indicating equal variances between the two groups. Therefore, the data were considered appropriate for parametric analysis.

**Table 10.** Homogeneity Test Results of Self-Efficacy

		Test of Homogeneity of Variance			
		Levene Statistic	df1	df2	Sig.
nilai	Based on Mean	.246	1	55	.622
	Based on Median	.245	1	55	.622
	Based on Median and with adjusted df	.245	1	54.990	.622
	Based on trimmed mean	.263	1	55	.610

An independent samples t-test assuming equal variances revealed a statistically significant difference in self-efficacy between the experimental and control groups,  $t(55) = -2.648$ ,  $p = .011$ . The experimental group obtained a higher mean score ( $M = 107.81$ ) than the control group ( $M = 99.40$ ).

The mean difference, computed as Experimental – Control, was  $-8.412$  with a 95% confidence interval of  $[-14.778, -2.047]$ . The magnitude of the difference was moderate to large, as indicated by Cohen's  $d = 0.71$ . These findings indicate a significant difference in mathematical self-efficacy between students who learned using the problem-solving-based LKPD with a sports context and those who received conventional instruction.

**Table 11.** T-test Results of Self-Efficacy

		Independent Samples Test								
		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
nilai	Equal variances assumed	.246	.622	-2.648	55	.011	-8.412	3.176	-14.778	-2.047
	Equal variances not assumed			-2.668	53.014	.010	-8.412	3.153	-14.737	-2.088

## Discussion

The findings of this study indicate that the problem-solving-based worksheet developed in this research is valid, practical, and effective for supporting mathematics learning on the Pythagorean Theorem topic. The discussion of these findings is presented based on the three main aspects of product evaluation, namely validity, practicality, and effectiveness in improving students' mathematical problem-solving ability and mathematics self-efficacy.

First, the validation results show that the developed worksheet meets the criteria of a highly valid instructional material. The expert evaluation covered several important aspects, including content accuracy, language clarity, presentation structure, and graphical design. The high validation scores indicate that the worksheet is aligned with the learning objectives and the characteristics of the Pythagorean Theorem material taught in junior high school. In addition, the CVR value of 1 confirms that the experts agreed that the components included in the worksheet were essential and appropriate for the learning process. These results suggest that the developed worksheet has a strong theoretical and instructional foundation. Previous studies have also highlighted that well-designed instructional materials can significantly support meaningful mathematics learning and guide students through structured problem-solving activities (Olivares et al., 2021a; Rittle-Johnson & Koedinger, 2005; Russell et al., 2022). Therefore, the validation results indicate that the developed worksheet is suitable to be implemented in classroom learning after minor revisions based on expert feedback.

Second, the practicality test results indicate that the worksheet is easy to use and feasible to implement in classroom learning. The students' responses show that the worksheet provides clear instructions and helps them understand the learning tasks more effectively. The contextual problems included in the worksheet also make the learning activities more engaging and meaningful for students. The high practicality score suggests that students can follow the learning steps in the worksheet without significant difficulties. In addition, the worksheet structure supports students in organizing their thinking process when solving mathematical problems. These findings are consistent with previous research indicating that structured worksheets can facilitate active learning and improve students' engagement in mathematics classrooms (Buffalari, 2022; Vale & Barbosa, 2023). Therefore, the developed worksheet can serve as a practical instructional tool for teachers to support problem-solving-oriented mathematics learning.

Third, the effectiveness analysis demonstrates that the use of the developed worksheet significantly improves students' mathematical problem-solving ability. The results of the independent samples t-test reveal a statistically significant difference between students who learned using the problem-solving-based worksheet and those who received conventional instruction. Students in the experimental group obtained higher mean scores in solving problems related to the Pythagorean Theorem. This improvement may be attributed to the learning activities embedded in the worksheet, which encourage students to analyze contextual problems, formulate mathematical models, and apply appropriate strategies to solve the problems. Through these structured activities, students are guided to engage actively in the problem-solving process rather than merely applying memorized formulas. This finding is consistent with previous studies showing that problem-solving-based instructional materials can significantly enhance students' mathematical reasoning and problem-solving skills (Olivares et al., 2021b; Son et al., 2020). Thus, integrating contextual problem-solving tasks into learning materials can contribute to improving students' conceptual understanding and mathematical competence.

Furthermore, the results also indicate that the developed worksheet positively influences students' mathematics self-efficacy. The experimental group demonstrated significantly higher self-efficacy scores compared to the control group. This result suggests that learning activities that involve guided problem-solving experiences can strengthen students' confidence in their mathematical abilities. When students are able to successfully solve contextual problems through structured steps, they develop a stronger belief in their capacity to overcome mathematical challenges. Previous research has emphasized that mathematics self-efficacy plays an important role in shaping students' persistence, motivation, and performance in solving mathematical problems (Stevens et al., 2004; Voica et al., 2020). Therefore, learning environments that provide opportunities for meaningful problem-solving experiences can contribute to improving students' confidence and attitudes toward mathematics learning.

Overall, the findings of this study highlight the importance of integrating both cognitive and affective dimensions in mathematics instruction. The problem-solving-based worksheet developed in this research not only improves students' mathematical problem-solving ability but also enhances their mathematics self-efficacy. By combining contextual learning situations with structured problem-solving activities, the worksheet provides meaningful learning experiences that encourage students to actively engage in mathematical thinking. These results suggest that well-designed worksheets can serve as an effective instructional strategy to improve the quality of mathematics learning in junior high school classrooms.

### Implications

Overall, the results of this study confirm that the integration of problem-solving approaches and contexts close to students' lives in mathematics teaching materials is an effective strategy to develop students' mathematical problem-solving skills and self-efficacy in a balanced manner. Thus,

the LKPD developed can be used as an alternative teaching material that supports meaningful mathematics learning and is oriented towards the development of students' cognitive and affective aspects.

### **Limitations and Suggestions for Future Research**

Based on the results of the research that has been obtained, there are several notes that can be used as a consideration as well as a direction for the development of learning and further research. The results of this study show that LKPD based on problem solving in the context of sports games can be used as an alternative teaching material in learning the Pythagorean Theorem, because it is able to improve students' mathematical problem-solving skills and self-efficacy. Therefore, mathematics teachers are advised to use this kind of LKPD to create more active, contextual, and student-centered learning, so that the learning process is not only oriented to solving problems, but also to developing students' thinking processes and positive attitudes towards mathematics.

However, this study has limitations that need to be considered. The research is only focused on one learning context, namely sports games, and is applied to the material of the Pythagorean Theorem at the junior high school level. Therefore, further research is recommended to develop LKPD with other contexts relevant to students' lives or apply them to different mathematics materials, so that a more comprehensive picture can be obtained of the effectiveness of problem-solving approaches in mathematics learning. In addition, follow-up research with a larger sample size and involving schools with more diverse characteristics needs to be carried out so that the results of the study have a wider generalization power.

### **CONCLUSION**

This study shows that tonal language pitch contours can be used as ethnomathematical objects to make abstract mathematical representations more contextual in higher education. When pitch variation from Thai, Mandarin, and Vietnamese is converted into frequency-time graphs, the contours display organized patterns that can be represented through constant, linear, quadratic, or sinusoidal models, making the relationship between variables observable and highlighting that mathematical structure can be traced within culturally embedded linguistic systems. In the learning activities, these pitch-based graphs supported students' graphical representation literacy by helping them interpret gradients, extrema, and patterns of change in a more meaningful way, while also prompting them to connect what they heard with what they saw and how they modeled it mathematically. Such multi-representational engagement encouraged structural awareness and relational reasoning that align with central features of Advanced Mathematical Thinking, suggesting that contextual grounding can deepen conceptual understanding without reducing analytical rigor. Overall, the study helps bridge ethnomathematics and AMT by demonstrating that cultural auditory phenomena can serve as both mathematically interpretable and pedagogically useful resources, offering a practical route to strengthen representational literacy while supporting higher-order reasoning at the tertiary level.

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### AUTHOR CONTRIBUTIONS STATEMENT

Both authors contributed significantly to this study. The first author was responsible for the conceptualization of the research, development of the worksheet, data collection, data analysis, and preparation of the manuscript. The second author contributed to the research supervision, validation of the instructional materials, data interpretation, and critical revision of the manuscript.

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