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Integrating problem-based learning in e-lkpd: Enhancing problem-solving ability and adversity quotients

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Abstract

Background: Students' mathematical problem-solving ability and adversity quotient remain low, particularly in learning environments that lack contextual approaches. Problem-based learning (PBL) has proven effective in improving these skills, especially when supported by interactive technology such as E-LKPD.
Aim: This study aims to develop a PBL-based E-LKPD that is valid, practical, and effective in enhancing students' problem-solving abilities and AQ.
Method: The research employed the ADDIE development model with eighth-grade students from SMP Negeri in Banjar Baru as the subjects. The practicality sample consisted of 6 students selected through purposive sampling, while the effectiveness sample included 60 students selected through random sampling. Data were collected through observations, interviews, questionnaires, and problem-solving tests, then analyzed using descriptive statistics and t-tests.
Result: PBL-based E-LKPD was deemed valid, with an average score of 87% from content experts and 85% from media experts. Its practicality was rated as excellent, with scores of 91% from both students and educators. An Independent Sample t-test on N-gain data indicated that the E-LKPD effectively improved students' mathematical problem-solving abilities and AQ (sig = 0.00 < α = 0.05).
Conclusion: The PBL-based E-LKPD has been proven valid, practical, and effective in enhancing students' mathematical problem-solving abilities and adversity quotient, making it a viable and innovative alternative in the learning process.

INTRODUCTION

Education serves as a foundation for shaping individuals who are skilled, knowledgeable, and prepared to face the challenges of the modern world. Among the various disciplines, mathematics holds a prominent position due to its role in fostering thinking. Mathematics is a vital part of Indonesia's educational curriculum and is mandatory at all levels of education, from elementary school to higher education, as outlined in the school curriculum structure (Anwar, 2018). The National Education Association introduced 21st-century mathematical competencies that human resources should possess, including critical thinking, problem-solving, collaboration, communication, and creative thinking skills (Awaliya & Masriyah, 2022; Kennedy at al., 2020). Mathematical proficiency is not limited to numerical calculation skills. It also encompasses the ability to reason logically and critically in solving problems (Pradana et al., 2024). Problem-solving

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extends beyond routine exercises and focuses on addressing real-life issues (Marni & Pasaribu, 2021). Therefore, mathematics instruction should be designed to help students comprehend and resolve contextual problems relevant to their lives, enabling them to apply problem-solving skills practically outside the classroom.

Problem-solving skills are not only essential for tackling academic exercises but also for helping students navigate daily life challenges, which are often fraught with obstacles. In addition to fostering the development of problem-solving abilities, students should also be facilitated in enhancing their adversity quotient (Komarudin et al., 2021). Stoltz (2005) defines adversity quotient as the intelligence that measures an individual's ability to persevere through challenges and overcome them, turning obstacles into opportunities. Adversity quotient predicts who will endure difficulties and who may easily give up in their pursuit of success (Stoltz, 2005). The response given significantly influences one's approach to solving problems. Consequently, adversity quotient is also regarded as an essential intelligence for students to develop, particularly in facing challenges within mathematics learning.

Mathematical problem-solving skills and students' Adversity Quotient are among the many abilities that need to be instilled. However, in reality, many students in Indonesia still struggle with mathematical problem-solving (Fenanlampir et al., 2019; Kusumadewi & Retnawati, 2020; Sujarwo & Sutiarso, 2023). The low level of mathematical problem-solving ability among Indonesian students is evident from the results of the Programme for International Student Assessment (PISA) survey, which assesses 15-year-old students. In the 2022 survey involving 81 countries, Indonesia's average score was far below the international average, achieving only 366 out of 500 points (Maqshum et al., 2019; Tanudjaya & Doorman, 2020). Similarly, in 2018, the mathematics performance score of Indonesian students was only 379 points, significantly below the international average score of 487 and much lower than the scores of other ASEAN countries (OECD, 2019). Results from the Trends in International Mathematics and Science Study (TIMSS) in 2015 echoed this trend, showing that Indonesian students ranked 44th out of 49 participating countries, with an average score of 397, well below the international average of 500 (Awaliya & Masriyah, 2022; Susanto et al., 2021). These findings highlight the urgent need for serious attention to improve Indonesian students' mathematical skills, particularly in problem-solving, through more innovative and contextual learning approaches.

Observing this phenomenon, the researcher analyzed the mathematics learning outcomes of eighth-grade students at a junior high school in Banjar Baru during the 2023/2024 Mid-Semester Summative Assessment. The data indicated that the students' mathematics achievement was still suboptimal. This aligns with the findings from interviews with the eighth-grade mathematics teacher, who reported that the low learning outcomes were due to students' poor understanding of basic concepts, particularly in geometry. During the learning process, teachers rarely provide opportunities for students to actively engage in drawing conclusions, indicating that the learning process remains teacher-centered. Additionally, the learning process has not yet integrated technology, with textbooks and worksheets still predominantly used by teachers.

One of the factors contributing to the suboptimal development of students' mathematical problem-solving skills and adversity quotient is the use of teaching media and instructional models. To address this issue, teachers need to innovate by incorporating educational media to ensure a more effective learning process (Aspi, 2018). E-LKPD is one of the technological advancements in education that plays a significant role (Andriana et al., 2022; Huda et al., 2023; Khoiri, 2023). Utilizing technological advancements such as E-LKPD in the learning process as a tool or support to streamline and simplify lessons while achieving learning objectives has shown positive impacts (Saputra et al., 2023). A study by Serlina (2022) also demonstrated that the implementation of E-LKPD in mathematics learning significantly enhances students' abilities to solve mathematical problems.

Innovation in the learning process is also essential. The problem-based learning model has proven effective in enhancing students' problem-solving skills. PBL provides students with opportunities to learn through direct experiences in solving real-world problems, encouraging them to actively seek solutions and independently understand concepts (Mayasari et al., 2016; Pratiwi & Setyaningtyas, 2020). Research indicates that the implementation of PBL significantly improves students' problem-solving skills, particularly in vocational and higher education settings (Hidayati & Wagiran, 2020; Indrawsari & Rahmat, 2022; Asyhari & Sifa'i, 2021). In this context, PBL not only enhances students' cognitive abilities but also facilitates the development of metacognitive skills, which are critical in the learning process (Susanto et al., 2023; Rohmawatiningsih et al., 2021).

The combination of problem-based learning and E-LKPD has been proven effective in improving students' problem-solving skills (Khoiri, 2023; Rani et al., 2024). Previous studies have shown that the use of interactive technology such as E-LKPD in PBL-based learning can enhance student engagement (Asrar et al., 2023), analytical thinking skills (Rohmawatiningsih et al., 2021), and responsibility (Çetin et al., 2023; Serlina et al., 2022). Additionally, the implementation of PBL supported by interactive technology enables students to address real-world problems more systematically, thereby improving their ability to solve complex problems (Sarman et al., 2023). However, while many studies have examined the impact of technology-based learning on improving problem-solving abilities, most of these studies have focused on cognitive aspects. The impact of interactive technology and PBL on non-cognitive aspects, particularly AQ, has rarely been explored. AQ is a crucial element in mathematics education, as it relates to students' resilience in facing difficulties and overcoming learning obstacles. Therefore, this study aims to fill this gap by developing a PBL-based E-LKPD to enhance problem-solving skills and adversity quotient that is valid, practical, and effective.

METHODS

Design:

This study is a Research and Development (R&D) study. Research and Development is a method aimed at producing a product and testing its level of effectiveness (Riza et al., 2022). The research design employs the ADDIE model, which consists of five stages: Analyze, Design, Development, Implementation, and Evaluation (Tegeh et al., 2014). The research workflow is illustrated in Figure 1.

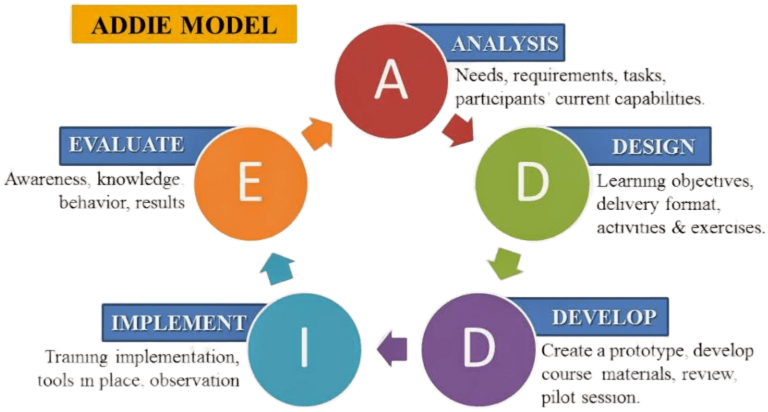

Figure 1. ADDIE Development Model

Participants:

This research was conducted in an eighth-grade class at a public junior high school in the Banjar Baru region. The validation subjects included media and content experts, whose expertise was essential to determine the validity of the developed E-LKPD. Subsequently, the trial subjects were eighth-grade students. The validation process by media and content experts involved professionals in their respective fields to ensure the E-LKPD's validity. The practicality of the E-LKPD was tested with a sample of 6 students selected through purposive sampling, while the effectiveness was tested with a sample of 60 students chosen through random sampling.

Instruments:

The instruments used in this study included E-LKPD validation sheets for content and media experts, student response questionnaires for the learning tools, teacher response questionnaires, problem-solving ability tests, and adversity quotient questionnaires. These instruments were designed to gather comprehensive data from both educational and practitioner perspectives to ensure the effectiveness of the E-LKPD implementation.

Data Analysis:

The data analysis techniques employed in this development research include qualitative descriptive analysis, quantitative descriptive analysis, and inferential statistical analysis. The validity of the E-LKPD was calculated using the following formula:

$$Validity\ Score = \frac{Total\ Score\ Obtained}{Maksimum\ Score} \times 100\%$$

Steps for Validity Analysis of the Problem-Based Learning-Based E-LKPD.

1. Assign scores to responses based on a Likert scale, depending on the criteria provided for each item
2. Determine the maximum score

$$Maximum\ Score = Jv \times Ji \times St$$

The information:
Jv = Number of Validators
Ji = Number of Questions
St = Highest Score on the Likert Scale

3. Sum all the scores assigned by each validator for all indicators.
4. Determine the Total Score Achieved
5. Calculate the Validity Value

The validation data will then be classified based on Table 1 below.

Table 1. Validity Index

Index (%)	Assessment criteria
90% – 100%	Very Valid
80% – 89%	Valid
65% – 79%	Fairly Valid
55% – 64%	Less Valid
≤ 55%	Invalid

After validating the developed E-LKPD, the next step is to conduct a practicality test of the product. This analysis aims to determine the practicality of the developed E-LKPD. The following formula is used to analyze the practicality value of the product (Mahardani et al., 2023).

$$P = \frac{Tse}{Tsh} \times 100\%$$

The information:
P = Practicality presentation
Tse = Empirical score
Tsh = Expected score

The practical test result data is then classified based on Table 2 below.

Table 2. Interpretation of Practicality

Index (%)	Information
85,01% – 100%	Very Practical
70,01% – 80,00%	Quite Practical
50,01% – 70,00	Less Practical
01,00% – 50,00%	Impractical

In this study, inferential statistical analysis was used to determine the effectiveness of the product on students' learning outcomes after being provided with the PBL-based E-LKPD in learning. Field trial data were collected by administering pre-tests and post-tests. The pre-test and post-test results were analyzed using an independent sample t-test with SPSS to identify differences between the pre-test and post-test results. Before hypothesis testing, prerequisite tests were conducted, namely the normality test and the homogeneity test.

RESULTS AND DISCUSSION

Result

Analysis – Evaluate

This stage involves analyzing the issues that arise during the learning process and assessing the needs of the research subjects. Several analyses are conducted during this stage. First, the needs analysis stage is carried out by examining the results of preliminary research. The findings from the preliminary research indicate that the problem-solving skills and Adversity Quotient of eighth-grade students are not yet optimal. This aligns with the results of interviews, where the mathematics teacher identified several factors contributing to the suboptimal learning outcomes. These include students' habitual reliance on information provided by the teacher, the use of teacher-centered learning models, and the reliance on printed teaching materials. Second, this stage involves analyzing the curriculum used by the school and identifying the materials taught. The analysis revealed that the school implements the Kurikulum Merdeka, with flat-sided solid geometry being one of the topics included in the Phase D learning outcomes. This analysis aims to understand students' abilities and characteristics. In the learning process, the teacher still relies on printed media as teaching materials, which is perceived as insufficient to enhance students' motivation to learn.

Design – Evaluate

After conducting the analysis, the next step is to design the E-LKPD to be developed. The activities carried out in this stage include:

1. Determining the structure of the E-LKPD aligned with the problem-based learning model. Activities include designing the cover, selecting themes, choosing images, determining font types and sizes, and selecting symbols appropriate to the teaching material.
2. The layout begins with a cover page, followed by an introduction, learning outcomes, learning objectives, content sections, and a closing section.
3. The initial design was created using Canva and then continued in Liveworksheet. The materials used in this study were sourced from the teacher’s guidebook and other relevant references.
4. At this stage, evaluations were conducted based on feedback and suggestions provided by academic advisors and curriculum analysis.

Development - Evaluate

At this development stage, the E-LKPD design created earlier using Canva was further refined. The final development process was completed using the Liveworksheet website, allowing the E-LKPD to be presented online for students. This platform enables students' work to be viewed directly. The developed E-LKPD can be distributed via links or QR codes. Figure 2 shows the development interface on the Liveworksheet website.

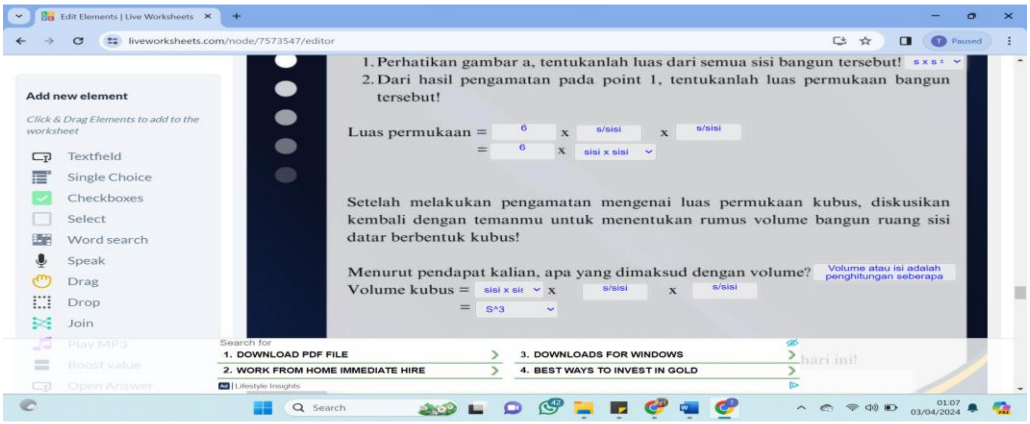

Figure 2. Development display via Liveworksheet

Figure 1 illustrates the development stages on the Liveworksheet website. The platform provides various element features such as text fields, single choice, checkboxes, and others. These element features are used to create answer fields that can later be filled in by students.

The developed product was subsequently evaluated during the validation stage by subject matter experts. The subject matter validation test was conducted to determine the validity of the flat-sided solid geometry content in the PBL-based E-LKPD. The validation process produced results in the form of validation scores and suggestions from the validators, which were used as references for improvements. The results of the subject matter expert validation are presented in Table 3.

Table 3. Material Validity Assessment Results

Category	**Validity Score**
Eligibility of content	87,50%
Feasibility of Presentation	85,94%
Total score	174,47%
Average	86,74%
Interpretation	**Valid**

The results of the media expert test are shown in Table 4 below.

Table 4. Media Validity Assessment Results

Category	**Validity Score**
Attractiveness	89,06%
Language Eligibility	82,29%
Total score	171.35%
Average	85,68%
Interpretation	**Valid**

Based on the analysis of questionnaires completed by six students regarding the PBL-based E-LKPD, the product achieved an average practicality score of 85.92%, categorized as highly practical. Additionally, the analysis of the teacher's responses to the developed E-LKPD resulted in a practicality score of 92%, also categorized as highly practical. The evaluation was conducted based on suggestions and feedback from validation participants to ensure the development of a high-quality E-LKPD.

Implementation – Evaluate

After determining the practicality of the product, a large-group trial was conducted to evaluate the effectiveness of the PBL-based E-LKPD. This was achieved by comparing learning outcomes between the experimental group, which used the PBL-based E-LKPD to enhance students' mathematical problem-solving skills and adversity quotient on flat-sided solid geometry material, and the control group, which did not use the E-LKPD as a learning medium. The learning activities began with a pretest and concluded with a posttest. The questions used to measure mathematical problem-solving skills were first validated for validity, reliability, difficulty level, and discrimination index. Similarly, the AQ questionnaire was validated and tested for reliability before use. The pretest and posttest scores are presented in the following table.

Table 5. Results of Mathematical Problem-Solving Ability Values

Information	Experiment Class		Control Class	
	Pre-test	**Post test**	**Pre-test**	**Post test**
Average	30.23	80.80	24.00	73.93
Max Value	48	94	40	86
Min Value	10	66	10	60

Table 6. Adversity Quotient Score Results

Information	Experiment Class		Control Class	
	Pre-test	**Post test**	**Pre-test**	**Post test**
Average	38.27	44.53	37.83	39.63

Evaluation

To assess the effectiveness of the E-LKPD, prerequisite tests such as normality and homogeneity tests were conducted. These tests were calculated using SPSS, and the results are presented in Table 8 and Table 9. Table 8 indicates that Sig>0.05\text{Sig} > 0.05Sig>0.05, meaning the data is considered normal. Similarly, Table 9 shows Sig>0.05\text{Sig} > 0.05Sig>0.05, indicating that the data is homogeneous.

Table 7. Summary of Normality Test Results for Problem Solving Tests

Class	Data	Sig.	Sig level.	Information
Experiment	*Pretest*	0.670	0.05	Normal
Control	*Pretest*	0.979	0.05	
Experiment	*Posttest*	0.084	0.05	
Control	*Posttest*	0.642	0.05	
Experiment	N-gain	0.223	0.05	
Control	N-gain	0.879	0.05	

Table 8. Summary of Adversity Quotient Normality Test Results

Class	Data	Sig.	Sig level.	Information
Experiment	*Pretest*	0.128	0.05	Normal
Control	*Pretest*	0.065	0.05	
Experiment	*Posttest*	0.091	0.05	
Control	*Posttest*	0.413	0.05	
Experiment	N-gain	0.421	0.05	
Control	N-gain	0.862	0.05	

After the data was declared normal, a homogeneity test was carried out. Analysis of homogeneity test results is shown in Table 9 and Table 10.

Table 9. Summary of Homogeneity Tests for Problem Solving Tests

Data	Sig.	Sig level.	Information
Pretest	0.359	0.05	Homogen
Posttest	0.152	0.05	
N-gain	0,0,60	0.05	

Table 10. Summary of Adversity Quotient Homogeneity Results

Data	Sig.	Sig level.	Information
Pretest	0.594	0.05	Homogen
Posttest	0.610	0.05	
N-gain	0.463	0.05	

From the table above, it can be concluded that the distribution of the data in the sample used is normal and homogeneous. Then a t test is carried out on the posttest and the N-gain scores of students' problem solving abilities and AQ.

Table 11. T Test Results Final Score of Problem Solving Test

Independent Samples Test						
		Levene's Test for Equality of Variances		*t-test for Equality of Means*		
		F	Sig.	t	Df	Sig. (2-tailed)
Posttest	*Equal variances assumed*	2,111	,152	3,644	58	,001
	Equal variances not assumed			3,644	53,415	,001

Based on Table 11, the significance value (2-tailed) is 0.001, which is less than the 0.05 significance level. So it can be concluded that there is a difference in the final ability (posttest) between the experimental class and the control class regarding students' problem solving abilities. Next, a t test was carried out on the N-gain value of students' mathematical problem-solving abilities which is presented in Table 12 below.

Table 12. Results of the N-gain t test for problem solving scores

Independent Samples Test						
		Levene's Test for Equality of Variances		*t-test for Equality of Means*		
		F	Sig.	t	Df	Sig. (2-tailed)
N-gain	*Equal variances assumed*	3,671	,060	2,758	58	,008
	Equal variances not assumed			2,758	48,947	,008

Based on Table 12, the significance value (2-tailed) is 0.008, which is less than the 0.05 significance level so H0 is rejected. So it can be concluded that there is a difference in the average N-gain increase in mathematical problem solving abilities of the group of students who use E-LKPD based on Problem Based Learning and the group of students who do not use E-LKPD based on Problem Based Learning. Next, a t test was carried out on the students' Adversity Quotient posttest, which is shown in Table 13 below.

Table 13. Results of the final Adversity Quotient Score t Test

Independent Samples Test						
		Levene's Test for Equality of Variances		*t-test for Equality of Means*		
		F	Sig.	t	Df	Sig. (2-tailed)
Posttest	*Equal variances assumed*	,263	,610	4,224	58	,000
	Equal variances not assumed			4,224	57,223	,000

Based on Table 13, the significance value (2-tailed) is 0.000, which is more than the 0.05 significance level. So it can be concluded that there is a difference in final ability (posttest) between the experimental class and the control class regarding the Adversity Quotient. Then a t test was carried out on the students' Ngain Adversity Quotient scores which are shown in Table 14 below.

Table 14. N-gain t Test Results Adversity Quotient Test Scores

Independent Samples Test						
		Levene's Test for Equality of Variances		*t-test for Equality of Means*		
		F	Sig.	Q	Df	Sig. (2-tailed)
N-gain	*Equal variances assumed*	,547	,463	4,499	58	,000
	Equal variances not assumed			4,499	57,784	,000

Based on table 14 above, the test results are listed in the significance section (2-tailed), namely 0.000, which is less than the 0.05 significance level so H0 is rejected. So it can be concluded that there is a difference in the average N-gain increase in Adversity Quotient for the group of students who use E-LKPD based on Problem Based Learning and the group of students who do not use E-LKPD based on Problem Based Learning.

Discussion

This study plays a significant role in mathematics education by producing electronic teaching materials called E-LKPD for flat-sided solid geometry topics. The utilization of the PBL-based E-LKPD was conducted in four sessions for the experimental class and distributed via the Liveworksheet platform. The E-LKPD is designed to be completed online by students, with results viewable in real-time. It eliminates the need for printed materials, allowing educators to distribute it through links or QR codes instead of paper-based formats.

The problem-based E-LKPD is designed to enhance student engagement in the learning process and includes mathematical problems connected to real-world contexts. Additionally, the stages in the problem-based learning (PBL) model incorporate a mathematics learning process that requires students not only to understand mathematical concepts but also to think critically and reason through solving mathematical problems. This model emphasizes process, where presenting problems serves as the starting point of learning, followed by finding solutions through problem-solving activities (Pratiwi & Setyaningtyas, 2020). By using real-world problems as contexts or challenges, the problem-based learning model helps students develop critical thinking and problem-solving skills. This approach also enables students to acquire key concepts and knowledge from the subject matter (Istiqomah et al., 2023). Furthermore, the problem-based learning model makes learning more enjoyable, interactive, and provides participants with more opportunities to practice, which in turn motivates them to learn (Afdillah et al., 2023).

The use of PBL-based E-LKPD demonstrates a positive contribution, as evidenced by the research findings. The utilization of electronic student worksheets simplifies students' learning activities through the support of technological advancements. With the aid of the Liveworksheet website, the teaching materials become more interactive. Additionally, the ease of accessing electronic student worksheets via links or QR codes, along with real-time feedback on student performance, enhances the learning process. The integration of technological advancements into the learning process as tools or supports to streamline and facilitate lessons, as well as to achieve learning objectives, has shown positive impacts (Saputra et al., 2023). Research by Saputra et al. (2023) also confirms that implementing technology-based media in classroom mathematics learning can significantly improve students' problem-solving skills.

Despite the advantages of using such media, this study, like others, is not without challenges. One limitation lies in the need for a stable internet connection. Factors affecting the practicality of using the E-LKPD include the novelty of teaching materials that leverage technology as a learning medium. The product, delivered through QR code links, provides convenience and a fresh learning experience for students. It eliminates the need for costly printing of teaching materials. Once the learning session is completed, students can immediately view their results through the E-LKPD, making it easier for teachers to monitor students' learning progress and evaluate the overall learning process.

The use of E-LKPD in the learning process has shown a significant positive impact on students' learning outcomes, particularly in enhancing their mathematical problem-solving abilities. Research by Mubharokh (2023) revealed that E-LKPD supported by the Liveworksheets application can improve students' mathematical problem-solving skills, aligning with the expectations of learning objectives. Additionally, Khikmiyah (2021) found that PBL-based E-LKPD not only enhances students' learning activities but also improves their problem-solving abilities. These findings indicate that E-LKPD serves as an effective evaluation tool for monitoring students' learning progress and assessing the overall learning process.

Implication

The results of this study are expected to provide benefits in integrating media into learning and enhancing students' mathematical problem-solving skills as one of the essential competencies for addressing 21st-century challenges. This study can contribute to four key areas: curriculum design, development of learning resources, continuous teacher training, and the incorporation of technology into classrooms. Specifically, for the topic of flat-sided solid geometry, the findings can serve as a reference for developing curricula and instructional strategies.

CONCLUSIONS

The PBL-based E-LKPD developed in this study has been proven to meet the criteria of validity, practicality, and effectiveness in enhancing students' mathematical problem-solving skills and adversity quotient (AQ) on the topic of flat-sided solid geometry. The validity of the E-LKPD was assessed by content experts, achieving an average score of 87%, and by media experts, achieving an average score of 85%, both categorized as valid. The practicality of the E-LKPD was rated as excellent based on feedback from students and educators, with an average score of 91%. Furthermore, the effectiveness test results indicated a significant value ($sig = 0.00 < \alpha = 0.05$), demonstrating that the use of this PBL-based E-LKPD effectively enhances students' mathematical problem-solving skills and AQ.

Future research could develop PBL-based E-LKPD for other mathematics topics or different educational levels to evaluate its adaptability. Additionally, long-term studies could be conducted to measure the sustained impact of E-LKPD on adversity quotient and problem-solving skills, as well as to explore its application in various educational contexts.

AUTHOR CONTRIBUTIONS STATEMENT

TPD : Conceptualization, module design, data analysis, and writing the manuscript.
SS : Supervision, guidance, and review.
RF : Data curation, validation, and editing.

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