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DEVELOPING AN INTERACTIVE PROJECT-BASED LEARNING E-LKPD TO FACILITATE CREATIVE MATHEMATICAL THINKING SKILLS

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Abstract

The urgency of this research is due to the limited learning resources that support the development of creative thinking in mathematics, which is an essential skill in the 21st century. This research aims to develop an interactive E-LKPD based on Project Based Learning (PjBL) that is valid, practical and effective in facilitating creative mathematical thinking skills in junior high school students.. The method used is research and development (R&D) by applying the 4-D model which includes the stages of defining, designing (design), development, and dissemination. The resulting product was tested for validity by a team of material and design experts with an average score of 3.28, and its practicality and effectiveness were assessed through student and teacher responses with an average total practical score of 3.5. Evaluation of improving mathematical creative thinking abilities using PjBL-based E-LKPD shows an average score of 80.86, which is included in the very high category with a completeness level reaching 89.65%. Thus, the PjBL-based E-LKPD is suitable for use because it meets the criteria of being valid, practical and effective. The implication of this research is the need for further development of the model used to produce products that are higher quality and more effective in supporting the creative mathematical learning process.

Keywords: Creative Thinking Ability; E-LKPD; Project Based Learning;

Abstrak

Urgensi penelitian ini dikarenakan masih terbatasnya sumber belajar yang mendukung pengembangan berpikir kreatif dalam matematika, yang merupakan keterampilan esensial di abad 21. Penelitian ini bertujuan untuk mengembangkan E-LKPD interaktif berbasis Project Based Learning (PjBL) yang valid, praktis, dan efektif dalam memfasilitasi kemampuan berpikir kreatif matematis pada siswa SMP. Metode yang digunakan adalah research and development (R&D) dengan mengaplikasikan model 4-D yang meliputi tahapan pendefinisian (define), perancangan (design), pengembangan (develop), dan penyebaran (disseminate). Produk yang dihasilkan diuji melalui validitas oleh tim ahli materi dan desain dengan skor rata-rata 3,28, serta kepraktisan dan keefektivannya yang dinilai melalui respon peserta didik dan guru dengan rata-rata total nilai praktis 3,5. Evaluasi peningkatan kemampuan berpikir kreatif matematis menggunakan E-LKPD berbasis PjBL menunjukkan skor rata-rata 80,86, yang termasuk dalam kategori sangat tinggi dengan tingkat ketuntasan mencapai 89,65%. Dengan demikian, E-LKPD berbasis PjBL layak digunakan karena telah memenuhi kriteria valid, praktis, dan efektif. Implikasi dari penelitian ini adalah perlunya pengembangan lebih lanjut pada model yang digunakan untuk menghasilkan produk yang lebih berkualitas tinggi dan efektif dalam mendukung proses pembelajaran kreatif matematis..

Kata kunci: E-LKPD; Kemampuan Berpikir Kreatif; Project Based Learning.



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INTRODUCTION

Education plays a key role in the development of the quality of human life. According to Malik (2018) education aims to improve the quality of human resources and must be measured by its success in preparing people to make meaningful contributions to the common good. Amid the accelerated development of information and communication technology (ICT), which according to Susanti (2021) and Setiawan (2018) is increasingly increasing, technology has had a significant impact on the education sector, triggering innovation in learning methods and techniques. Technology creates new breakthroughs in learning and expands learning activities, which are now moving from traditional classroom methods to unlimited internet methods, allowing children to learn independently without teacher support or guidance (Nurdalilah, Harahap, Nasution, & Lubis, 2023; Ruskandi, Pratama, & Asri, 2021).

Creative thinking skills are very important in mathematics courses, which are universal subjects that develop thinking, communication, problem solving, and reasoning skills. Mailani, Setiawati, Surya, & Armanto (2022) emphasized that creativity in mathematics is important because it is not only about memorizing formulas, but how students can develop their creative thinking. However, Fitriyah & Ghofur (2021) noted that the low level of students' creative thinking skills is often because they only memorize formulas without understanding mathematical concepts. Another contributing factor is the absence of teaching materials specifically to form students' mathematical creative thinking skills. In fact, the supporting media used in learning have utilized technology, it's

just that students have not fully trained themselves by trying to practice problems independently to improve their creative thinking.

Although technology has been widely integrated into mathematics education, there is still a gap in the development of learning materials that can effectively address this issue. Pribadi et al. (2021) and Puspita & Dewi (2021) suggest that interactive E-LKPD in learning activities is a means for teachers to provide information, attitudes, and skills to students so that learning becomes interesting and attractive. And the electronic devices such as PC/laptop and mobile phones can be used to quickly access interactive E-LKPD (Octaviana, F., Wahyuni, D., & Supeno, 2022; Ratnawati, 2021). This E-LKPD can include an attractive design with visuals and learning videos, as well as a Google Form link that allows students to answer questions more easily and communicate directly with the teacher.

This study aims to address these challenges and enhance students' creative thinking skills in mathematics by developing an engaging interactive E-LKPD. The primary goal of this research is to design and assess the effectiveness of an interactive E-LKPD based on project-based learning as a tool to improve students' creative mathematical thinking skills, while also contributing to more modern and applicable mathematics education literature.

METHODS

a. Type of Research

The type of research conducted is the research and development method (Sugiyono, 2017). The final product is teaching material in the form of an interactive E-LKPD based on Project-

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Based Learning, designed to enhance students' creative thinking skills in mathematics

b. Development Model

In this development research, the 4D model is utilized, serving as a source of ideas and procedures for developing learning materials (Putri, Roza, & Maimunah, 2020). The 4D model is frequently utilized in the research and development of teaching materials, such as E-LKPD and textbooks (Shalahuddin & Hayuhantika, 2022).

c. Development Procedure

The development model used refers to the 4D model. The 4D model stands for Define, Design, Development and Dissemination developed (Syarfina et al., 2022).

1) Define

This stage involves an analysis of learning needs, starting with an analysis of the objectives and limitations of the material for the development of E-LKPD.

2) Design

a. Preparation of E-LKPD

Preparing E-LKPD materials includes identifying basic competencies, integrating supporting information such as real-life images, using material sources such as guidebooks and everyday experiences, and selecting clear sentences and good and correct language.

b. E-LKPD Media Selection

The selection process is adapted based on analyzing the concepts, tasks, and learning media available within the school.

c. Format Selection

Adapting the E-LKPD format to the desired format.

3) Develop

The development stage produces materials in the form of E-LKPD that

have been revised based on expert input and validated by expert teachers and practitioners.

4) Disseminate

The implementation of the developed E-LKPD is carried out on a larger scale, e.g. in other classes or schools, to test the effectiveness of using the material in learning activities (Ruhmana et al., 2023).

d. Research Instruments

The research instruments utilized included questionnaires and tests. Questionnaires were used for students who had used the E-LKPD and experts to validate the developed E-LKPD. In this study, researchers employed several development research instruments, focusing on aspects of validity, practicality, and effectiveness. The validity aspect was used to obtain data on the content and construct validity of the developed E-LKPD.

e. Data Analysis Technique

Data were obtained using research instruments which will be analysed. Data analysis is conducted to explain or demonstrate the achievement of criteria for validity, practicality, and effectiveness of the developed product, specifically the effectiveness of the Learners' Worksheet (E-LKPD) based on Project-Based Learning.

1) Data Analysis of Validity

Table 1. Criteria of Validity

Value	Criteria
$3,5 \leq V \leq 4$	Very valid
$2,5 \leq V < 3,5$	Valid
$1,5 \leq V < 2,5$	Quite valid
$0 \leq V < 1,5$	Invalid

(Cubrich et al., 2021)

The validity of the research product was assessed by several validators, namely validators who are

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experts in the preparation of E-LKPD. The criteria for validity used in this assessment are presented in Table 1.

2) Effectiveness Data Analysis

The effectiveness of the developed LKPD was analysed through learning outcomes tests. Data on students' learning outcomes were analysed quantitatively with descriptive statistics to measure students' mastery of the material after completing the learning process. Learners' abilities can be categorised on a scale of five based on a standard categorisation technique set. The categories for determining learner learning outcomes are presented in Table 2.

Table 2. Category Score Determination of Learner Learning Outcomes

Value	Category
0-34	Very low
35-54	Low
55-64	Medium
65-85	High
85-100	Very high

3) Practicality Test Data Analysis

Learner response questionnaires were analysed by percentage. Activities carried out to analyse learner response data, for more details can be seen in Table 3.

Table 3. Learner Assessment Criteria

Value	Criteria
$3,6 \leq Xi \leq 4$	Very positive
$2,6 \leq Xi \leq 3,5$	Positive
$1,6 \leq Xi \leq 2,5$	Quite positive
$0 \leq Xi \leq 1,5$	Not positive

RESULTS AND DISCUSSION

The development process of the E-LKPD follows four main stages in the 4-D model: Define, Design, Develop, and Disseminate. The final product

produced is an E-LKPD prototype that has been validated and well received in the context of creative mathematics learning.

a) Defining Stage

The main activities include identifying learning needs and gathering relevant information. This includes analyzing the existing curriculum, identifying the needs of students and teachers, and understanding the learning context in which the E-LKPD will be used. The aim of this stage is to ensure that the E-LKPD developed meets real needs in the field and is based on clear learning objectives.

b) Design Stage

The development team designed the first prototype of the E-LKPD. This stage includes selection of appropriate materials, interaction and user interface design, and effective integration of learning media. This prototype was designed taking into account feedback from initial stakeholders and adapting to the technology available in the schools where E-LKPD will be implemented.

c) Development Stage (Develop)

This stage involves further development of the prototype based on input from the initial evaluation phase. In this phase, Prototype I was evaluated by a team of experts to ensure the validity of its content and design. Based on the improvement suggestions provided by the two validators, prototype I was revised accordingly, resulting in prototype II. After addressing the deficiencies in prototype I as per the validators' recommendations, prototype II was then evaluated by the validators. The results of the E-LKPD validation assessment are presented in Table 4.

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Table 4. Average Validator Assessment Results

Assessment Aspect	Assessment Results	Category
Content Appropriateness	3	Valid
Accuracy and Correctness of Materials	3,25	Valid
Component Presentation	3,5	Very valid
Language Use	3,25	Valid
Component Completeness	3,3	Valid
Graphic Feasibility	3,37	Very valid
Average	3,28	Valid

Based on Table 4, the average score from the validator's assessment of the Project-Based Learning-based E-LKPD is 3.28, which falls into the valid category. Aspects assessed include suitability of content, accuracy and correctness of material, presentation of components, use of language, completeness of components, and appropriateness of graphics. This E-LKPD can be utilized with minor revisions based on the validators' suggestions.

Then, the research instrument in the form of a questionnaire was first validated before use. The questionnaires created include student response questionnaires and teacher response questionnaires. After the questionnaire is made, the questionnaire is then validated by the validator by providing suggestions and input to the questionnaire, then giving an assessment of the questionnaire based on the aspects on the validation sheet in order to obtain a valid questionnaire. These results can be seen in table 5 and Table 6.

Table 5. Description of the Validation Results of the Learner Response Questionnaire

Assessment Aspect	Assessment Results	Category
Guidance aspect	4	Very Valid
Response Coverage Aspect	3	Valid
Language Aspect	4	Very valid
Average	3,66	Very valid

Table 5 shows that the validation results of the student response questionnaire yielded a score of 3.66, which falls into the very valid category. Therefore, it can be concluded that the learner response questionnaire can be used with minor revisions. Aspects assessed include guidance, scope of response, and use of language. Similarly, the teacher response questionnaire was also validated, and the results are presented in Table 6.

Table 6. Description of Teacher Response Questionnaire Validation Results

Assessment Aspect	Assessment Results	Category
Guidance	4	Very valid
Response Coverage	3	Valid
Language	4	Very valid
Average	3,66	Very valid

Table 6 depicts the validation of the teacher response questionnaire with similar results, an average score of 3.66, also in the very valid category, so it can be concluded that the teacher response questionnaire can be used with minor revisions.

The learning outcomes test that has been made, then validated by the validator using a validation sheet to determine the validity of the creative

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thinking test in order to obtain valid results. The detailed results of the validator assessment are presented in Table 7.

Table 7. Description of the Results of Validator Assessment of Creative Thinking Test

Assessment Aspect	Assessment Results	Category
Material	3	Very valid
Constrution	3,3	Valid
Language	3,5	Very valid
Average	3,27	Very valid

Table 7 showed the validation results of the creative thinking test showing an average score of 3.27, which is in the very valid category. Aspects assessed include material, construction, and use of language. This test is valid and ready to use with some minor improvements.

d) the Dissemination stage

Finally, at the Dissemination stage, the refined E-LKPD is implemented on a wider scale. This involves testing the E-LKPD in a real classroom setting at school. This test was carried out to see the practicality and effectiveness of Interactive E-LKPD based on PjBL in improving students' mathematics learning outcomes and creative thinking skills.

1) Practicality of E-LKPD Based on Project Based Learning

The practicality of the Project-Based Learning E-LKPD can be evaluated through the results of student and teacher response questionnaires. These questionnaires contain statements regarding their responses to the E-LKPD developed by the researchers. The results of these response questionnaires are presented in Table 9.

Table 9. Overall Response Results

No	Type of assessment	Average
1	Teacher Response	3,65
2	Student Response	3,35
Average Total		3,5
Assessment Criteria		Positive

Based on Table 9, it can be concluded that the assessment category derived from the students' questionnaire results is positive towards the developed E-LKPD. Additionally, students are interested in participating in learning activities supported by the Project-Based Learning E-LKPD. The criteria for the practicality of E-LKPD based on Project Based Learning can be said to be achieved and practically used in the learning process.

2) The Effectiveness of E-LKPD Based on Project Based Learning

The effectiveness of the Project-Based Learning E-LKPD can be assessed from the results of the student learning outcomes test administered after the E-LKPD is implemented in the classroom. The test consists of 20 multiple-choice questions. This learning outcomes test is given to students to evaluate their understanding of the material provided through the PjBL-based E-LKPD. The students' learning outcomes are presented in Table 8

Table 8. Percentage of Creative Thinking Completeness

Category	Frequency	KKM
Learners who completed	26	
Learners who did not complete	3	75
Percentage of learners' completeness	89,65%	
Students		

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Based on Table 8, it can be concluded that the number of students who obtained learning completeness above the KKM was 26 people with the KKM standard of 75. While students who obtained completeness below the KKM were 3 people. The percentage of students' completeness obtained is 89.65% which is in a very high category. Based on the data above, it can be that E-LKPD based on Project Based Learning is effectively used in the learning process. learning process.

The results of this research reinforce the understanding that integrating Project-Based Learning (PjBL) into E-LKPD significantly enhances junior high school students' mathematical creative thinking abilities. The high validity of the materials and instruments used indicates that the design and content of the E-LKPD are well-suited for this learning context, as reflected in the validation scores and positive responses from both students and teachers.

The main finding of this research is the effectiveness of E-LKPD in improving students' creative mathematics learning outcomes. High scores in creative thinking tests and a success rate of 89.65% in achieving or exceeding the KKM indicate substantial improvements in students' mathematical understanding and skills.

The factors that contributed to the results of this study consist of several key elements. First, the interactive and attractive design of E-LKPD has been proven to increase student engagement significantly. As explained by Alamri, Lowell, Watson, & Watson (2020; Melati et al. (2023) the use of technology in education can facilitate deeper and more interesting learning experiences, which is very important in motivating students.

Second, the use of PjBL allows students to participate actively in the learning process. This approach, in accordance with research by Setiawan (2018) supports students in applying mathematical concepts in real situations, thereby increasing their understanding of the material practically and theoretically. Third, the quality of well-designed content is fundamental. The material presented in E-LKPD is prepared to ensure accuracy and relevance to students' learning needs, in line with the findings of Fitriyah & Ghofur (2021), who emphasizes the importance of understanding concepts rather than simply memorizing formulas. All of these factors collaborate to create an effective learning environment, enabling students to not only understand but also apply mathematical knowledge in creative and effective ways.

The strengths of this research include the systematic use of 4-D models in the development of E-LKPD and a strong focus on content validation. However, drawbacks may include sample limitations, which are largely limited to one school setting, which may not fully represent the broader student population.

This research is in line with the findings Harahap & Abidin (2021); Mardhiyah, Aldriani, Chitta, & Zulfikar (2021) who emphasize the importance of innovative learning approaches and technology in education. However, in contrast to Fitriani (2022); Fitriyah & Ghofur (2021) who shows that students often only memorize formulas without in-depth understanding, the E-LKPD developed in this research is designed to overcome this problem by supporting a stronger conceptual understanding.

The implications of this research are significant for curriculum

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development and learning materials. Effective use of E-LKPD can be adopted by other schools to increase students' mathematical creativity, providing a stronger foundation for STEM education. Additionally, these results offer a contribution to the mathematics education literature by providing empirical evidence about the benefits of using technology and the PjBL approach in mathematics education.

CONCLUSIONS AND SUGGESTIONS

This research succeeded in developing E-LKPD based on PjBL by following the 4-D development model, which includes the stages of definition, design, development and distribution. The E-LKPD developed has been valid with an average score of 3.28 after two revisions, showing high practicality with an average score of 3.5, as well as very high effectiveness in improving student learning outcomes, with 89.65% of students achieve learning completion. These findings confirm that a project-based learning approach through the use of E-LKPD can significantly improve students' mathematical skills and understanding.

Considering the results of this research, there are several recommendations that can be used as guidelines for further research in an effort to optimize the use of E-LKPD based on Project Based Learning. To ensure that this E-LKPD is effective in various educational environments, it is recommended to apply it in diverse contexts and different age groups. This will provide broader data on the adaptability and effectiveness of E-LKPD, allowing for necessary adjustments to better suit diverse educational needs. With the rapid

development of technology, it is highly recommended to integrate the latest tools such as augmented and virtual reality in E-LKPD. It is hoped that this will not only increase interactivity and attract students' interest in learning but also help in increasing understanding of more complex mathematical concepts through a more immersive learning experience.

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