

Development of E-LKPD Based on Project Based Learning in IPAS Subjects to Improve Students' Critical Thinking Skills

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Abstract: his study aims to develop an Electronic Student Worksheet (E-LKPD) based on Project-Based Learning (PjBL) for the Natural and Social Sciences (IPAS) subject to enhance the critical thinking skills of elementary school students. The research was conducted at SD Negeri 4 Pringgabaya, where traditional teaching methods using printed worksheets were found to be monotonous and less engaging, leading to decreased student motivation. The E-LKPD was designed using the LiveWorksheets platform, incorporating multimedia elements such as audio, video, and interactive questions to make learning more engaging and effective. The development process followed the Research and Development (R&D) method, simplified from Borg and Gall's model, and included stages such as needs analysis, planning, product development, validation, and testing. The E-LKPD was validated by material and design experts, with results indicating high validity and practicality. Effectiveness tests conducted in small and large groups showed significant improvements in students' critical thinking skills, as measured by pre-test and post-test scores using the N-Gain score. Student and teacher feedback also indicated high satisfaction with the E-LKPD, categorizing it as "very good" for use in the learning process. The study concludes that PjBL-based E-LKPD is an effective tool for enhancing critical thinking skills and can be a valuable resource for modern, technology-integrated education.

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Introduction

Education plays a crucial role in shaping intelligent individuals and creating a quality human resource base. In the era of the 4.0 industrial revolution, the rapid advancement of technology demands the education sector to continuously innovate and adapt. Technological education, which involves the use of technology in the learning process, has become one of the keys to enhancing students' learning experiences and preparing them to be proficient in utilizing technology across various aspects of life. Technology not only facilitates access to information but also serves as an essential tool in supporting effective and efficient learning processes, (Haleem et al., 2022; Sher & Lee, 2004).

The role of technology in education has become increasingly vital as time progresses. Technologies such as laptops, smartphones, and computers have become inseparable from daily life, including in the field of education. These tools enable students to access information quickly, complete tasks more easily, and develop the skills needed in the digital era. According to (Umaroh & Bahtiar, 2022), technology is the development and application of tools, machines, materials, and processes that help humans solve problems. In the context of education, technology not only simplifies the teaching and learning process but also opens opportunities for the development of more interactive and engaging learning methods.

Technological advancements have also driven significant changes in the education system. The internet, as one of the products of technology, has become a highly effective learning medium. Through the internet, students can access information from various parts of the world quickly and communicate in real-time. This has encouraged schools and educational institutions to provide adequate facilities, such as electronic devices and stable internet connections, to ensure optimal learning processes. (Sinaga, 2023), states that technological progress has enabled easier access to information and communication, requiring the education sector to continuously adapt to these changes.

Education is not only about mastering subject matter but also about developing students' skills to face various life challenges. According to (Bahri, 2017), the purpose of education has two main functions: providing direction and serving as the goal to be achieved through educational activities. Effective learning requires a deep understanding of how students can develop their potential, whether in school, in the community, or within the family. (Franco-Mariscal et al., 2024; Jia & Tu, 2024; Yassin, 2024) emphasize that learning is a process of personal change that includes the enhancement of knowledge, skills, critical thinking, understanding, attitudes, and various other abilities.

Teachers, as the frontline in the learning process, play a critical role in creating an effective learning environment. The personality and competence of teachers significantly influence students' success. Teachers must not only master the subject matter but also be able to use engaging and effective learning media. In the digital era, teachers are required to utilize technology in the learning process, such as interactive learning media that can increase students' interest and motivation. One such learning medium is the Electronic Student Worksheet (E-LKPD) based on Project-Based Learning (PjBL). E-LKPD is a digital form of worksheets that can be accessed through electronic devices such as smartphones, laptops, or computers. This medium not only simplifies the learning process but also enhances student engagement and creativity.

Based on observations at SD Negeri 4 Pringabaya, it was found that teachers still use printed worksheets limited to brief materials and conventional questions. This makes learning monotonous and less engaging, resulting in a decline in students' motivation, particularly in the subjects of Natural and Social Sciences (IPAS). To address this issue, innovative solutions are needed to increase student engagement and critical thinking skills. E-LKPD based on PjBL is one alternative that can be used to achieve this goal. This E-LKPD is designed using the Live Worksheets platform, which allows teachers to include multimedia such as audio, video, and links, as well as various types of interactive questions. Additionally, E-LKPD based on PjBL can activate students' independent learning through challenging projects.

Critical thinking is one of the essential skills that students must possess. According to Simbolon, critical thinking includes the ability to analyze, evaluate, and organize information logically. (Angelina et al., 2024; Song et al., 2024; Zeybek, 2025), defines critical thinking as thinking that meets standards of adequacy and accuracy. E-LKPD based on PjBL can be an effective medium for training students' critical thinking skills, as the projects provided encourage students to analyze problems, seek solutions, and evaluate their work.

Previous research by (Putri et al., 2022), showed that the use of PjBL-based worksheets significantly improved students' critical thinking skills. The results of the study indicated that the majority of teachers considered PjBL-based worksheets to be very practical, with a high category improvement in students' critical thinking abilities. Similar research by (Almulla, 2023), also proved that scientific method-based learning tools could enhance students' critical thinking skills in globalization topics. The results showed that the learning tools used met the criteria of being valid, effective, and practical.

However, previous development products were still limited to conventional teaching materials, which are less flexible and less effective. To maximize the quality of education, a transformation from traditional media to information and communication technology (ICT)-based media is needed. One form of this transformation is the replacement of conventional teaching materials with electronic materials, such as E-LKPD. Therefore, this research aims to develop PjBL-based E-LKPD for IPAS learning to improve the critical thinking skills of elementary school students. The developed E-LKPD is expected to be easily accessible through electronic devices such as smartphones, laptops, or computers. The purpose of this research is to describe the validity, practicality, and effectiveness of PjBL-based E-LKPD in improving the critical thinking skills of elementary school students.

Research Method

This research employs the Research and Development (R&D) method, as outlined by Sugiyono (Okpatrioka, 2023). R&D is a research approach aimed at producing specific products and testing their effectiveness. The process involves analyzing needs to develop a product and conducting tests to ensure its functionality for broader use. The final output of this research is an Electronic Student Worksheet (E-LKPD) based on Project-Based Learning (PjBL). According to Borg and Gall, Educational R&D is a process used to develop and validate educational products, (Fahrurrozi & Mohzana, 2020). In essence, this research aims to create a product tailored to enhance the learning process.

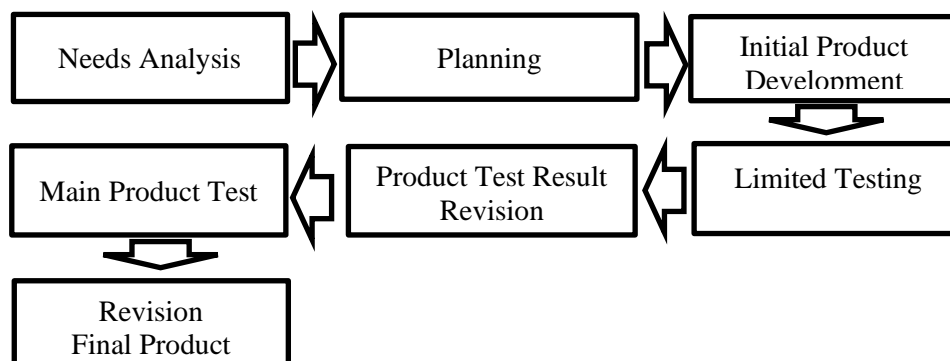


Figure 1. Simplified Borg and Gall Research and Development Design

The development procedure follows a simplified version of Borg & Gall's design, reduced from 10 steps to 7 due to limitations in time and resources. The steps include:

1. Needs Analysis
 - a. Conduct observations of the learning process in Grade 5 at SDN 4 Pringgabaya.
 - b. Interview Grade 5 teachers regarding learning evaluation practices.
 - c. Analyze available supporting facilities and student characteristics.
 - d. Identify the need for E-LKPD as a tool to make learning more engaging and effective.
2. Planning
 - a. Determine the IPAS (Natural and Social Sciences) topics for Grade 5 to be integrated into the E-LKPD.
 - b. Select learning objectives related to topics such as food chains and webs.
 - c. Develop a question grid for the E-LKPD.
3. Initial Product Development
 - a. Develop the PjBL-based E-LKPD according to the product specifications.
 - b. Conduct validation tests with material and design experts.
 Material Validation: Conducted by teachers or subject matter experts to ensure alignment with curriculum standards.
 Design Validation: Conducted by experts in design to evaluate the layout and readability of the E-LKPD.
4. Limited Testing
 - a. Test the practicality of the E-LKPD with a small group of users.
 - b. If the product does not meet practicality criteria, revisions are made and retested.
5. Product Revision Based on Testing
 - a. Refine the product based on feedback from the limited testing phase.
6. Main Product Testing
 - a. Conduct large-scale testing with Grade 5 students as the primary subjects.
 - b. Use student and teacher questionnaires to assess the effectiveness and practicality of the E-LKPD.
 Student Feedback: Assesses the attractiveness and usability of the E-LKPD.

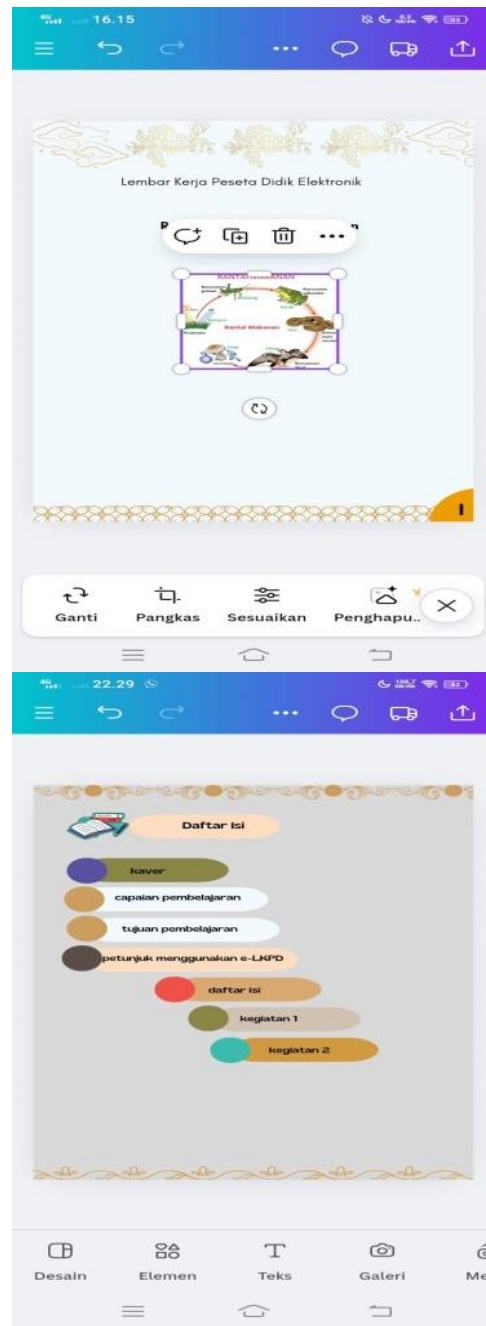
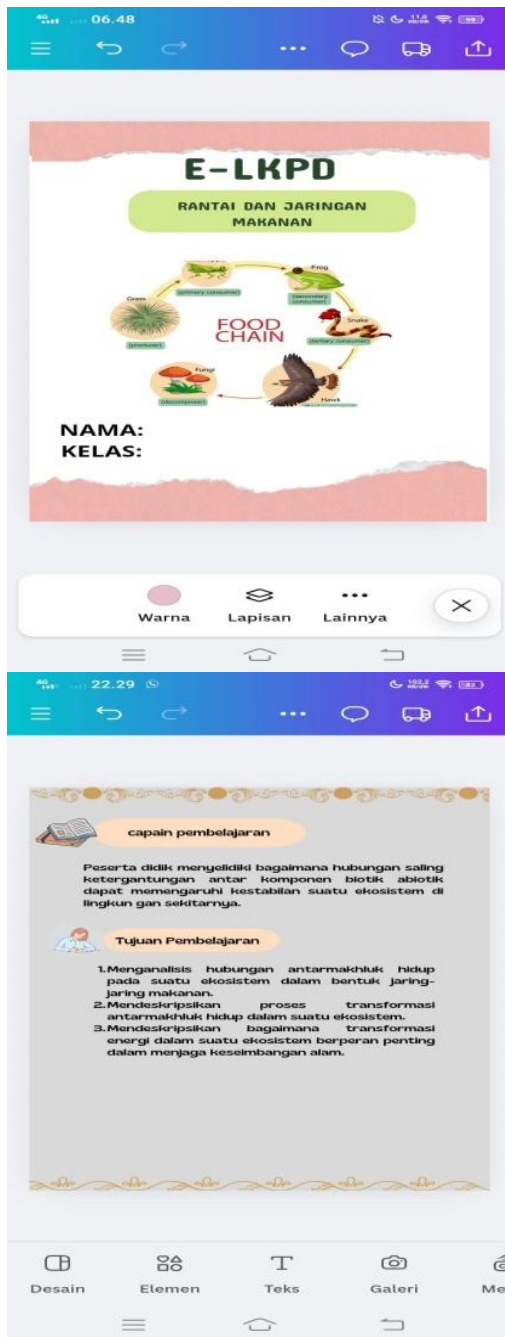
- Teacher Feedback: Evaluates the practicality of the E-LKPD in classroom settings.
7. Final Product Revision
 - a. Finalize the product based on feedback from the main testing phase.
 - b. If the product meets the criteria, no further revisions are needed. Otherwise, additional refinements are made.
 8. Product Testing Design
 - a. Subjects: Grade 5 students at SDN 4 Pringgabaya during the 2024 academic year.
 - b. Data Types: Qualitative Data: Obtained from comments, suggestions, and observations by validators and teachers; Quantitative Data: Collected through scores from questionnaires, validator assessments, and student evaluations.
 - c. Instruments:
 1. Expert Validation Sheets: Used for material and design validation.
 - Material Validation Sheet: Evaluates the content's alignment with learning objectives.
 - Design Validation Sheet: Assesses the visual and functional aspects of the E-LKPD.
 2. Questionnaires: Used to gather feedback from students and teachers on the product's practicality and effectiveness.

This methodology ensures the development of a valid, practical, and effective E-LKPD product to enhance critical thinking skills in Grade 5 students.

Result and Discussion

Initial Product Development Validation Results

The third stage is the development stage, at this stage researchers begin to develop PjBL-based E-LKPD IPAS in accordance with the product specifications that have been made. Researchers also make covers, learning outcomes, learning objectives, instructions for using E-LKPD, table of contents, activity 1, and finally activity 2.



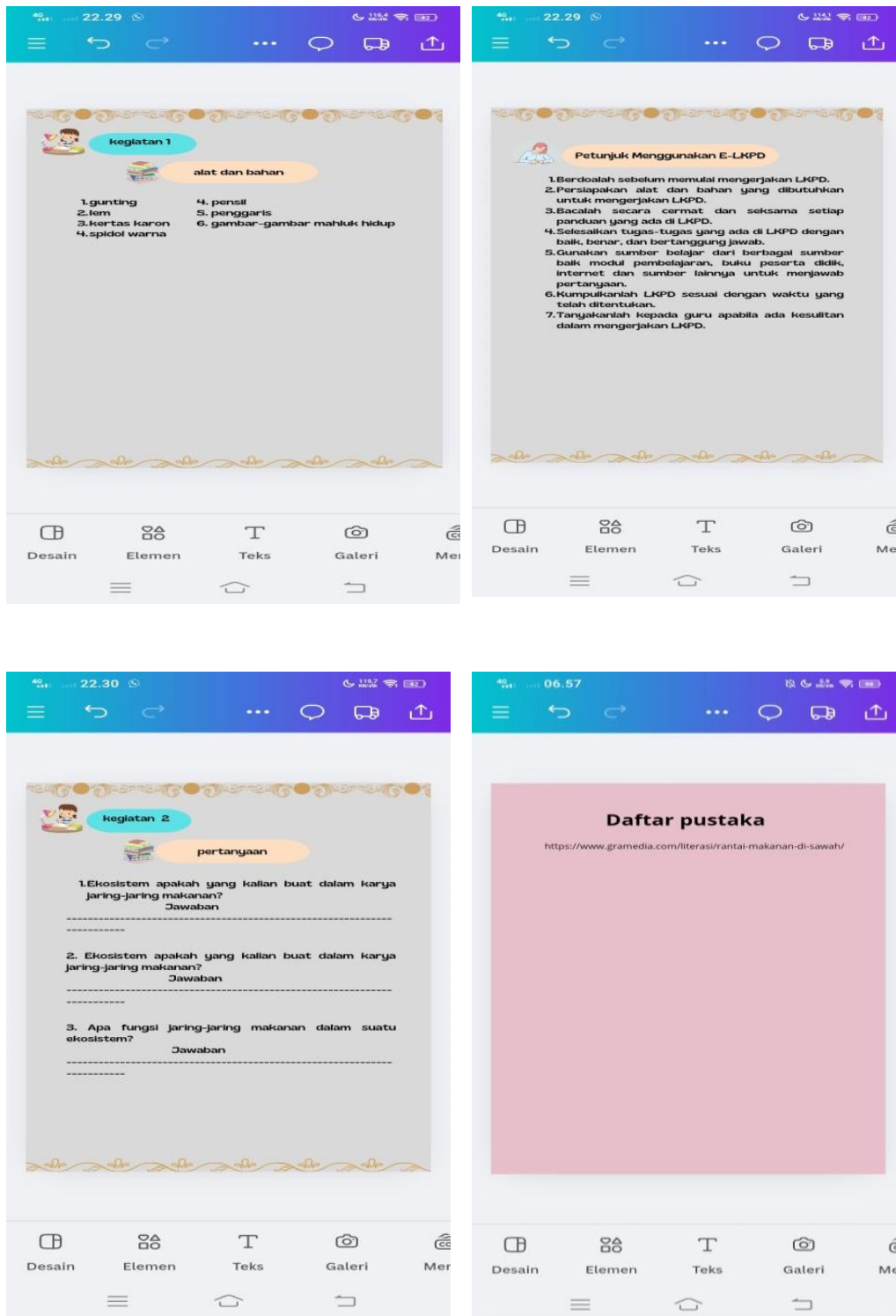


Figure 2. Initial product Development

Product Design Expert Validation Results

a. Material Expert Validation Results

Material expert validation was carried out by Hamzanwadi University science lecturers in the field of material, namely Dr. Muhammad Khaerul Wazni, M.Pd. This validation was carried out on 19-23 September 2024. Based on the material expert validation, the product in the form of E-LKPD IPAS developed by the researcher obtained a score of 46, in the range of scores $X > 46.14$. From the results of the total score, it can be categorised as 'Good'.

Table 1. Material Expert Validation

No	Aspek	Pertanyaan	Interval
1	Language and writing	Effectiveness of the sentences used	4
		Appropriateness of language use with students' developmental level	4
		Effectiveness and efficiency of language	4
		Communicative/easy to understand	4
		Readability of writing by students	4
		Clarity of sentence structure	4
2	Use of E-LKPD in Learning	Generate learners' interest in learning	5
		Motivates students to understand the material	5
		Student interactivity on E-LKPD IPAS	4
		Clarity of instructions for using E-LKPD IPAS	4
		Student independence using E-LKPD IPAS	4
Quantity			46
Kategori			Good

b. Display Design Expert Validation Results

Display design expert validation was carried out by lecturer Dr. Fahrurrozi, MM. on 14 October 2024. As a lecturer at Hamzanwadi University who is an expert in the field of display design. The results of the display design expert validation show that the product in the form of PjBL-based E-LKPD IPAS developed by researchers is valid and feasible to develop, obtaining a score of 69 and is in the $X > 63$ score range. From the results of the total score, it can be categorised as 'Very Good'.

Table 2. Display Design Expert Validation

No	Aspek	Pertanyaan	Interval
1	Cover Design	The cover page is in accordance with the character of grade V students.	5
		The cover page is attractive and clear	5
		The opening page of each lesson is titled	5
		There are instructions for using the E-LKPD	5
2	Contents Design	The position of the text does not spoil the appearance of the image	5
		The font type in the content of the E-LKPD used is easy for students to read	4
		The use of images that attract students to enjoy learning	4
		The colouring of the text creates a non-boring effect	4

		Placement of illustrations in accordance with their location so that it makes it easier to understand the material	4
		There is a bibliography	4
3	Design of Information Presentation	Consistency in the location of the numbering on the E-LKPD	4
		Consistency of writing size for numbering	5
		The layout of the images on the E-LKPD creates a non-boring effect while children are learning using the E-LKPD	4
		Image suitability with student development	5
		Does not use foreign terms that have multiple meanings	5
		Quantity	69
		Category	Very good

c. Critical Thinking Instrument Validation Results

Material expert validation was carried out by Hamzanwadi University science lecturers in the field of material, namely Dr. Muhammad Khaerul Wazni, M.Pd. this validation was carried out on 23 September 2024. Based on the material expert validation, the product in the form of E-LKPD IPAS developed by the researcher obtained a score of 51, in the range of scores $X > 50.4$. From the results of the total score, it can be categorised as 'Very Good'.

Table 2. Validation of Critical Thinking Instrument Questions

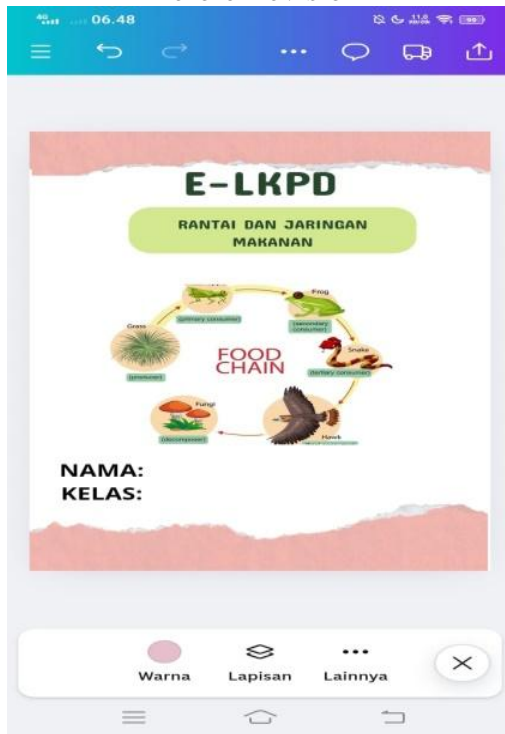
No	Aspek	Pertanyaan	Interval
1	Question material	In accordance with the learning objectives in the teaching module	5
		In accordance with the domain to be measured, namely critical thinking skills	4
		Raised from the problems encountered by researchers at school	4
2	Languages used	The language of the material presentation is easy to understand	4
		Appropriateness of language used with students' language skills	4
		The language used is communicative	4
		Language in accordance with refined spelling	4
		Grammatical accuracy	4
		There is no double interpretation of the words used	4
3	Rubric of assessment	Contains the components to be measured	4
		Rubric components are in accordance with the question	5
		There are scoring guidelines for each item	5
		Quantity	51
		Category	Very good

Results of the Final Revision of the Product Design of Electronic Learner Worksheets with Project Based Learning

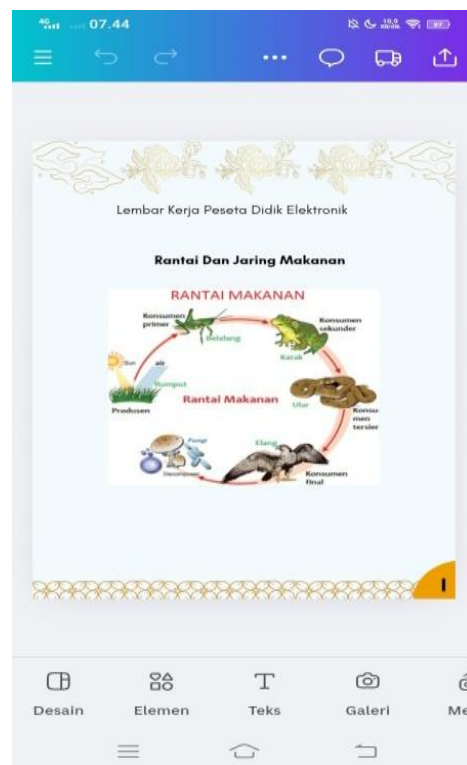
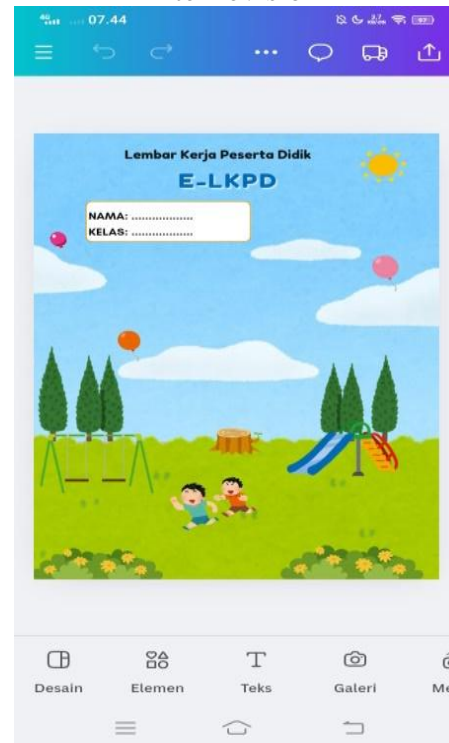
Data analysis of validation results conducted by media experts regarding the developed PjBL-based E-LKPD can be categorised as valid. Input or suggestions are as follows:

- The cover uses more bright and elegant colours in accordance with the characteristics of students
- Images are attempted to be larger
- Bibliography strive for the last three years

Before Revision



After revision



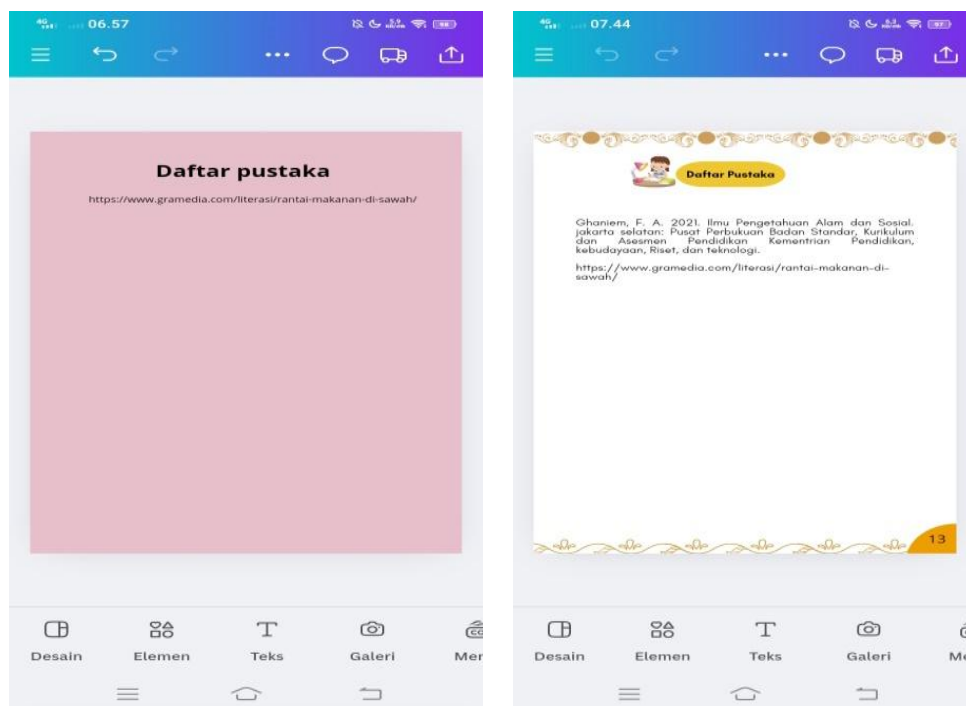


Figure 2. Final Product Revision

a. Results of the Effectiveness Test in Small Groups

Based on the effectiveness test in small groups, it can be seen the average value obtained by students during the pre-test and posttest. At the time of the pre-test there were seven students who scored below the KKM with an average score of 53.6 and at the time of the posttest there were two students who scored below the KKM with an average score of 82.9. To find out the effectiveness of the PjBL-based E-LKPD that has been developed can be analysed using the N-Gain score. N-Gain Score is the difference between pre-test and posttest scores and can show an increase in understanding after the learning process using the product that has been developed. The E-LKPD has been evaluated in a small group effectiveness test at SDN 4 Pringgabayad with 10 students. Analysis of the effectiveness test using the N-Gain score, namely in the pre-test that has been done getting the average value of students of 53.6 and the results of the posttest that has been done getting an average value of 82.9. So that the calculation of the category of acquisition of the interpretation of the effectiveness of N-Gain percent (%) gets a value of 63.47 with a fairly effective category and based on the calculation of the effectiveness test using the N-Gain score division gets a value of 0.63 with moderate criteria. So it can be concluded that the PjBL-based E-LKPD is effective to be used as teaching material in the learning process.

Table 3. Small Group Testing

Calculation of N-Gain Score						
No	post test	pre-test	post-pre	skor ideal (100-pre)	N Gain score	N Gain score (%)
Mine	82.9	53.6	29.3	46.4	0.63	63.47

b. Results of Product Effectiveness Test in Large Groups

Based on the effectiveness test in the large group, it can be seen the average value obtained by students during the pre-test and posttest. At the time of the pre-test there were fifteen students who scored below the KKM with an average score of 51.3 and at the time of the posttest there were two students who scored below the KKM with an average score of 85.75. To find out the effectiveness of the PjBL-based E-LKPD that has been developed can be analysed using the N-Gain score. N-Gain Score is the difference between pre-test and posttest scores and can show an increase in understanding after the learning process using the product that has been developed. E-LKPD has been evaluated in the large group effectiveness test at SDN 4 Pringgabayad with 20 students. Analysis of the effectiveness test using the N-Gain score, namely in the pre-test that has been done getting the average value of students of 51.3 and the results of the posttest that has been done getting an average value of 85.75. So that the calculation of the category of acquisition of the interpretation of the effectiveness of N-Gain percent (%) gets a value of 70.20 with a fairly effective category and based on the calculation of the effectiveness test using the N-Gain score division gets a value of 0.70 with high criteria. So it can be concluded that the PjBL-based E-LKPD is effective to be used as teaching material in the learning process.

Table 4. Large Group Test Results

Small Group Testing						
Calculation Of N-Gain Score						
No	post test	pre-test	post-pre	skor ideal (100-pre)	N Gain score	N Gain score (%)
Mine	85.75	51.3	34.45	48.7	0.70	70.72

c. Results of Student Response Questionnaires

The main product test was carried out by filling out a student response questionnaire filled out by grade V students of SDN 4 Pringgabaya on 12 November 2024 with a total of 20 respondents. The results of the analysis of the student response questionnaire obtained a total of 1376 with an overall average of 68.8 in the score range $X > 63$. From the results of the overall score, it can be categorised as 'Very Good'. There are five categories that can be used as a reference, namely:

Table 5. Student Response Questionnaires

Sum of Scores	Average	Category
1376	68,8	Very good
	4,6	

d. Results of Teacher Response Questionnaire

The observer activity was carried out by the teacher, namely the fifth grade teacher Mrs Fuad Zakiatun, S.Pd, religion teacher Mr. Hamdi Rahman, S.Pd. M.Pd, and grade 1 teacher Mrs. Huriati, S.Pd. whose task is to assess the activities of the PjBL-based E-LKPD Teaching

Materials directly. The assessment obtained from the observer can be used as a basis so that it can determine the feasibility level of the PjBl-based E-LKPD. Based on the data from the teacher observation sheet that has been filled in by the observer, there are learning activities using PjBL-based E-LKPDs showing that the number of points that the observer fills more 'Yes' in the response on the teacher observation sheet, namely 15 points and if it is percented to 100% compared to the response 'No' which is 0%, meaning that the teacher's activity in carrying out learning activities using PjBL-based E-LKPDs meets the good category or can be said to be good.

Discussion

The implementation of Electronic Learner Worksheets based on Project Based Learning can be done in small groups and large groups. Data collection related to the effectiveness questionnaire against E-LKPD is also collected with the implementation activities. The evaluation stage is carried out to analyse the test results that have been collected previously and assess the E-LKPD that has been applied in learning. The results of the pretest and posttest analysis collected showed that there was a difference in average results. The posttest results are higher than the pretest so it can be said that the use of E-LKPD has effective criteria to improve students' critical thinking skills.

While in learning activities using PjBL-based E-LKPD teaching materials that require students to be more active and independent in teaching and learning activities. Where by using this PjBL-based E-LKPD teaching material requires students to learn actively and train students to produce a project. With teaching materials like this, it will have an impact on students' learning achievements, abilities and critical thinking skills. According to Trilling and Fadel, critical thinking skills can be trained through project-based learning driven by authentic questions and problems (Usman et al., 2024), This is also clarified by the findings of this study, namely the PjBL-based E-LKPD helps students in developing critical thinking skills through project tasks that require analysing, evaluating, and solving problems. Related to critical thinking skills will be assessed based on the theory obtained. that is, summarising the results of the discovery process so that it can solve the problem (De Leng et al., 2009). In addition to providing a more interesting learning experience, this method is expected to usually improve students' critical thinking skills (Anica-Popa et al., 2024). According to Ratna et al., critical thinking is the ability to think logically, reflectively, systematically, and productively applied in making judgements and making good decisions, (Isnaeni, 2024), Learners are able to make better decisions when designing IPAS projects related to the material studied, increasing learner engagement and motivation to learn. Learners are more enthusiastic in doing the project because it is supported by the experimental steps in the E-LKPD. The PjBL-based E-LKPD encourages group work thus improving learners' collaboration skills. E-LKPDs provide easy access anytime and anywhere to support distance learning, and learners can complete project tasks at home by utilising E-LKPD guides accessed through their devices.

The E-LKPD developed by researchers to provide opportunities for students to try to understand the material learned independently with the help of making a project. The PjBL model used also helps students develop critical thinking skills. According to Pasaribu and Simatupang, the PjBL model can help students in group learning, develop their skills and the

projects they work on can provide personal experience to students and also emphasise student-centred learning activities (Saro'i, 2024), This research has an important role in the development of IPAS learning that focuses on developing students' critical thinking skills. therefore, PjBL-based E-LKPD can be used as a good strategy to improve students' critical thinking skills.

Furthermore, the effectiveness of learning using teaching materials that have been developed shows maximum results seen from the questionnaire test of students' learning and students seem motivated to use teaching materials in the form of PjBL-based E-LKPD and the learning process is very effective, and students look enthusiastic and enthusiastic in carrying out learning using PjBL-based E-LKPD. Furthermore, data on the results of observations from class teachers show that the teaching materials developed really make students enthusiastic in the learning process. The assessment obtained from the observer can be used as a basis so that it can determine the feasibility level of the PjBL-based E-LKPD. Based on the data from the teacher observation sheet that has been filled in by the observer, there are learning activities using PjBL-based E-LKPDs showing that the teaching materials are very effective and feasible to use.

Conclusion

This development research has produced PjBL-based E-LKPD IPAS teaching materials that are very effective for use in learning. This development procedure refers to the Borg and Gall development which has been simplified into 7 stages, namely (1) needs analysis (2) planning, (3) product development (4) initial field trial (5) revision of learning media (6) field implementation test (7) final revision and learning media products. PjBL-based E-LKPD IPAS teaching materials have been validated by 2 experts, The validation results from media experts resulted in an actual score of 69 with an average of 4.6 which means the validity of teaching materials is very good. For material experts, the actual number of scores is 46 with an average of 4.2, which shows that the material covered in teaching materials by researchers can be said to be suitable for use in the learning process. Furthermore, the last observer assessed the delivery of researchers in the classroom using the media that had been developed with a total score of 1376 with an average of 68.8, which shows that the product developed in the form of PjBL-based E-LKPD IPAS teaching materials for grade 5 students of SDN 4 Pringgabaya can be categorised as 'very good / very suitable for use in the learning process.

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