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THE FEASIBILITY OF PROJECT-BASED LEARNING E-WORKSHEET ON THE TOPIC OF ECOSYSTEMS FOR TRAINING PROBLEM-SOLVING SKILLS IN GRADE X HIGH SCHOOL STUDENTS

Kelayakan E-LKPD Berbasis Project Based Learning Topik Ekosistem untuk Melatih Keterampilan Pemecahan Masalah Peserta Didik Kelas X SMA

Matiin Indi Safitri
Biology Education, Mathematics and Science Faculty, Universitas Negeri Surabaya
E-mail: matiinindi.21023@mhs.unesa.ac.id

Tarzan Purnomo
Biology, Mathematics and Science Faculty, Universitas Negeri Surabaya
E-mail: tarzanpurnomo@unesa.ac.id

Abstract
Problem-solving skills are one of the important abilities that students need to have in order to face the challenges of the 21st century. This study aims to produce an E-LKPD based on Project Based Learning (PjBL) on ecosystem to train the problem-solving skills of 10th grade high school students, based on the validity and completeness of the students' cognitive learning outcomes. This study used the 4-D model (Define, Design, Develop, and Disseminate), with a limited trial involving 20 tenth-grade students at SMAN Jogoroto, Jombang. The validity instruments consisted of 19 items covering presentation, content, and language, which were adapted to the PjBL learning model and problem-solving indicators. This assessment was conducted by media experts, subject matter experts, and high school biology teachers using a Likert scale of 1-4 (poor-very good). The completeness of cognitive learning outcomes was assessed through the completion of pre-test and post-test using the N-Gain value calculation based on the school's minimum passing grade (KKM). Data analysis was conducted using quantitative descriptive analysis. The validity based on the presentation aspect was 98.33%, the content aspect was 98.08%, and the language aspect was 100%. Overall, the validity score was 98.80% (highly valid). The cognitive learning outcomes of the students achieved an average score of 88 and an N-Gain of 0.76, categorized as high improvement. Based on these results, the E-LKPD based on PjBL on the ecosystem topic is deemed suitable for implementing problem-solving skills training for 10th-grade high school students, as evaluated by validity and cognitive learning outcomes.
Keywords: E-LKPD, Project-Based Learning, ecosystem, problem-solving, validity.

Abstrak
Keterampilan pemecahan masalah merupakan salah satu kemampuan penting yang perlu dimiliki peserta didik dalam menghadapi tantangan abad 21. Penelitian ini bertujuan untuk menghasilkan E-LKPD berbasis *Project Based Learning* (PjBL) pada materi ekosistem guna melatih keterampilan pemecahan masalah peserta didik kelas X SMA yang layak, berdasarkan validitas dan ketuntasan hasil belajar kognitif peserta didik. Penelitian ini menggunakan model pengembangan 4-D (*Define*, *Design*, *Develop*, dan *Disseminate*), uji coba terbatas pada 20 peserta didik kelas X SMAN Jogoroto, Jombang. Instrumen penelitian validitas meliputi 19 butir yang terdiri dari aspek penyajian, isi, dan bahasa, telah disesuaikan dengan model pembelajaran PjBL serta indikator pemecahan masalah. Penilaian ini dilakukan oleh ahli media, ahli materi, dan guru biologi SMA menggunakan skala *Likert* 1-4 (kurang baik-sangat baik). Ketuntasan hasil belajar kognitif dinilai melalui pengerjaan soal *pre-test* dan *post-test* menggunakan perhitungan nilai *N-Gain* dengan berdasarkan pada nilai KKM sekolah. Teknik analisis data secara analisis deskriptif kuantitatif. Hasil validitas E-LKPD berdasarkan kelayakan aspek penyajian sebesar 98,33%, kelayakan aspek isi sebesar 98,08%, dan kelayakan bahasa sebesar 100%. Sehingga secara keseluruhan memperoleh skor validitas sebesar 98,80% (sangat valid). Ketuntasan hasil belajar kognitif peserta didik memperoleh rata-rata sebesar 88, dan *N-Gain* sebesar 0,76 dengan kategori peningkatan tinggi. Berdasarkan hasil tersebut, E-LKPD berbasis PjBL pada materi ekosistem dinyatakan layak diterapkan dalam melatih keterampilan

pemecahan masalah peserta didik kelas X SMA ditinjau dari validitas dan tes hasil belajar kognitif peserta didik.
Kata Kunci: E-LKPD, *Project Based Learning*, ekosistem, pemecahan masalah, validitas.

INTRODUCTION

Education plays a strategic role in shaping quality human resources through the development of critical thinking and problem-solving skills. In the context of the 21st century, these skills are packaged in the 4C concept (Critical Thinking, Communication, Collaboration, Creativity), which has become the main focus of curriculum development in various countries, including Indonesia. In line with the implementation of the Merdeka Curriculum, education in Indonesia is directed toward a flexible, adaptive, and learner-centered approach, with an emphasis on character building and mastery of essential competencies. During the learning process, students are encouraged to become accustomed to solving problems, identifying what is needed, and using their thinking to understand and apply knowledge (Dewi & Purnomo, 2023).

Problem-solving skills are individual skills in utilizing thinking processes to solve a problem. This process involves gathering facts, analyzing information, formulating various alternative solutions, and selecting the most effective solution (Rahma, 2020). Problem solving as a learning process enables students to learn concepts and principles for solving problems. This learning creates answers to problems (products) and how to solve problems (processes). These skills are very important to develop in students because problems cannot be solved directly without first understanding their causes. Through problem-solving skills, students will become accustomed to using relevant theories and concepts to solve problems (Ramdhani *et al*., 2022). The problem-solving process can be achieved with problem-solving indicators according to Polya in Purba *et al.* (2021), namely analyzing problems, developing strategies, implementing strategies, and reviewing results. Facts show that the achievement of problem-solving skills among students is still low.

One of the main problems in biology education at the high school level is the low problem-solving skills of students. Based on the results of international assessments (PISA), the science literacy of Indonesian students is still low, reflecting a lack of skills in identifying problems, evaluating information, and formulating relevant solutions. At the local level, observations and interviews with biology teachers also indicate that the low problem-solving skills are influenced by teaching methods that are not contextually relevant and the limited availability of learning materials.

In line with the current state of education, the global agenda through the Sustainable Development Goals (SDGs) places quality education as one of its main goals. Improving the quality of education includes developing a relevant and future-oriented curriculum that is capable of producing individuals who are competitive, environmentally conscious, and critical thinkers (Ruci, 2020). One of the major themes in the SDGs is ecosystem preservation (Goal 15), which is relevant to biology learning in schools. Through learning that instills ecosystem awareness, students are expected to understand the importance of environmental sustainability and its role in maintaining ecosystem balance. In the E phase of the ecosystem topic, students are required to have a deep understanding of the relationships between biotic and abiotic components in an environment. Students need to understand how these interactions maintain ecosystem balance and the impacts of disruptions to this balance, such as loss of biodiversity, environmental pollution, or climate change. This understanding is not only theoretical but also requires problem-solving skills, such as the ability to analyze the causes of ecosystem disturbances, formulate relevant solutions, and evaluate the impacts of these solutions on the environment.

Based on the results of research conducted in several public secondary schools, it can be concluded that the average problem-solving skills of students reached 46%, indicating that these skills are still relatively low (Modok, 2021). In terms of problem-solving skills, students need assessment instruments to train their problem-solving abilities and enable them to solve various problems (Perdana, 2023). Research in several secondary schools found that students often experience difficulties in understanding abstract concepts related to interactions between components (abiotic and biotic), energy flow, and biogeochemical cycles. This is also supported by the lack of interactive learning methods, so that students tend to be less interested or find it difficult to understand concepts in depth (Ilmiah, 2024).

Interviews with biology teachers at SMAN Jogoroto Jombang showed that students' problem-solving skills are still relatively low. This is due to the limited use of effective media, such as visual aids or simulations, in explaining abstract material. Additionally, the lack of

practical activities or field observations, differences in students' abilities, insufficient relevance of the material to real-world environmental issues, and evaluations that tend to focus on memorization also pose challenges. The low problem-solving skills of students are reflected in their learning outcomes, where the majority have not achieved the Minimum Passing Criteria (KKM) in several evaluations, and their scores on analysis or complex problem-solving tasks are below 70%. The tendency toward memorization and the lack of interest in literacy among students also pose challenges in understanding the concepts of the material. A more contextual and interactive approach, such as project-based learning, the use of technology, and hands-on practice, is needed to address these issues (Tambunan, 2019).

Previous studies have examined the effectiveness of learning models in improving 21st-century skills. Project-based learning (PjBL) is known to create active, meaningful, and contextual learning (Putri, 2018). PjBL provides opportunities for students to engage in projects that are relevant to real life, including environmental and ecosystem issues. The results of Jaenudin's (2020) and Amalia & Isnawati's (2023) studies indicate that PjBL can significantly improve problem-solving skills. However, in practice, the integration of PjBL into systematic learning media, especially in the form of digital E-LKPD, has not been optimally developed.

There is a lack of project-based learning tools designed digitally and interactively, especially for ecosystem topics. Yet, this material is highly potential for integration with real-world environmental problem-based projects that can foster scientific awareness and skills among students. Therefore, the development of E-LKPD based on Project Based Learning is an innovative solution to bridge the learning needs of the 21st century, support the implementation of the Merdeka Curriculum, and improve the quality of concept understanding and problem-solving skills.

The objective of this study is to develop an E-LKPD based on PjBL for ecosystem material that is valid and effective in training problem-solving skills among 10th-grade high school students. This study is expected to contribute to improving the quality of learning media and fostering active, creative, and contextual learning processes in biology classrooms.

METHOD

This research is a development of E-LKPD using the 4D model (define, design, develop, and disseminate). The product developed is E-LKPD on the topic of ecosystems that applies PjBL to train students' problem-solving skills. The 4D development model begins with the definition stage (define), which involves analyzing the curriculum, students, concepts, and tasks to be studied, as well as formulating learning outcomes. The next stage is the design stage, which involves the preparation of E-LKPD through review and revision. The third stage is development, in which the draft E-LKPD is validated by validators until it is declared valid and then tested on a limited scale. Limited testing and evaluation were carried out at SMAN Jogoroto Jombang with 20 students. This development continues until the E-LKPD is declared feasible, valid, and effective, resulting in a final draft. The dissemination stage involves refining the product and disseminating it widely to users.

The variables in this study include validity and effectiveness. Validity is assessed by media experts, subject matter experts, and high school biology teachers regarding the PjBL-based E-LKPD using a validation sheet. The validation sheet is filled out using a Likert scale of 1-4 with categories 1 (poor), 2 (fair), 3 (good), and 4 (very good) when answering the provided statements. This assessment is considered valid if the validity percentage is ≥ 75%. Effectiveness is assessed through the completeness of students' cognitive learning outcomes through learning with E-LKPD. These results were obtained through an analysis of the pre-test and post-test answers completed by the students. The analysis was conducted using the N-Gain score.

$$Gain\ score = \frac{posttest\ score - pretest\ score}{100 - pretest\ score}$$

Each problem-solving skill indicator was analyzed to determine the completeness of cognitive learning outcomes in accordance with the school's minimum competency standard of 75.

$$Percentage\ (\%) = \frac{\sum student\ who\ have\ completed}{\sum all\ students} x100$$

E-LKPD with PjBL on ecosystem material is considered effective in training problem-solving skills if it meets a percentage score of ≥ 75% with effective or highly effective criteria.

RESULT AND DISCUSSION

The results of this development research are electronic student activity sheets based on Project Based Learning on

the topic of ecosystems to train valid and effective problem-solving skills. This study produced data in the form of E-LKPD development results, validity results reviewed by expert assessment, and effectiveness results reviewed from the completeness of students' cognitive learning outcomes.

E-LKPD Based on Project Based Learning

The electronic student activity sheets developed contain activities based on the complete stages of Project-Based Learning (PjBL). In this study, E-LKPD also includes several features tailored to the characteristics of PjBL learning and problem-solving skills, namely B-Think, B-Insight, B-Project, B-Schedule, B-Logbook, B-Task, and B-Feedback. These features aim to support the improvement of problem-solving skills, which is the objective of this study. The various features included in the E-LKPD make it more engaging (Table 1).

Table 1. Display and Features of E-LKPD

No.	Display and Features	Description
1.		Front cover and back cover of the E-LKPD
2.		Display of E-LKPD feature introduction integrated with Project Based Learning learning syntax and problem-solving skills
3.		The B-Think feature contains analytical questions to encourage students to analyze problems so that they can generate ideas to solve problems based on articles related to the issue of ecosystem imbalance caused by tofu waste.
4.		The B-Insight feature contains key information providing facts related to ecosystem balance and the impact of industry on the environment, as well as the characteristics of tofu waste to be processed as a project and examples of how to make liquid organic fertilizer products.
5.		The B-Project feature contains instructions for students to design experiments related to liquid organic fertilizer made from tofu liquid waste and innovative additives.
6.		The B-Schedule feature contains instructions for students on how to schedule activities for the liquid organic fertilizer project, including implementation on plants. In this feature, the schedule is prepared with guidance from the teacher and is agreed upon by the students and teacher to ensure that it is structured and achieves maximum results.
7.		The B-Logbook feature contains records of student activities during project development, referring to the agreed schedule. In this feature, students record the activities they have done along with documentation and challenges encountered during the project. In this feature, students record the activities they have done along with documentation and challenges encountered during the project.

No.	Display and Features	Description
8.		The B-Tasks feature contains instructions for students on how to create presentation media as a result of the project activities that have been carried out. This feature also serves as a means for students to review the results obtained and check the success of the activities that have been carried out. In addition, it also contains practice questions that test students' understanding and application of the topic of ecosystem balance.
9.		B-Feedback feature, contains feedback from students based on the results of project activities or questions that have been studied.

These features are tailored to the PjBL syntax (determining fundamental questions, planning projects, scheduling, monitoring student work and project progress, assessing results, and evaluating experiences) and problem-solving skill indicators, namely analyzing problems, planning strategies, implementing strategies, and reviewing results. The PjBL model can improve problem-solving skills. This is in line with the results of research by Pratiwi & Purnomo (2025), which states that PjBL-based student activity sheets are appropriate and can train critical thinking skills. Meanwhile, research by Solong, *et al*. (2022) states that there is an influence of the PjBL learning model on the problem-solving abilities of students at SMPN 5 Kota Bima.

The application of project-based learning models in a learning environment provides meaningful experiences and supports the improvement of problem-solving skills. Activities on E-LKPD are adapted to the PjBL syntax and problem-solving skill indicators through the features presented. The B-Think feature contains articles that train students to analyze problems and determine fundamental questions.

Then, students are directed to plan a project through the B-Project feature as a solution to the problems that have been analyzed (strategy planning indicator). Students can access information to support project planning through the B-Insight feature until the stage of preparing a schedule in the B-Schedule feature. In the project implementation process, which is the strategy implementation indicator, students record the progress of the project through the B-Logbook feature. In this feature, teachers monitor student performance. Students record project outcomes through the B-Tasks feature until preparing presentation materials as part of the assessment syntax and the indicator for reviewing outcomes. At the end of the learning process, there is the B-Feedback feature for evaluating the learning experience using the PjBL-based E-LKPD.

Validity of E-LKPD Based on Project Based Learning

The validity of E-LKPD was assessed based on presentation, content, and language. This assessment was conducted to evaluate the feasibility of the developed product, namely E-LKPD. E-LKPD was assessed by three validators, namely a media expert lecturer, a subject matter expert lecturer, and a high school biology teacher (Table 2).

Table 2. Recapitulation of E-LKPD Validation Results

No.	Aspects Assessed	Score			Average (%)	C
		V1	V2	V3		
A.	**Presentation**					
1.	**Quality of E-LKPD Use**					
	a. E-LKPD can be accessed easily	4	4	4	100	VV
	b. Page navigation is easy	4	4	4	100	VV
	c. Links available in E-LKPD can be accessed easily	4	4	4	100	VV
	d. Can be accessed using a laptop/mobile phone	4	4	4	100	VV
2.	**Quality of E-LKPD Cover Display**					
	a. The E-LKPD cover depicts the ecosystem topic	4	3	3	83,33	VV
	b. The E-LKPD title is consistent with the ecosystem topic	4	4	4	100	VV
	c. The images presented are relevant to the ecosystem topic	4	4	4	100	VV
	d. The composition of layout elements (title, author, logo, illustration) is appropriate	4	4	4	100	VV
	e. The font type and size are appropriate	4	4	4	100	VV
3.	**Layout Quality**					
	a. Text in the E-LKPD is easy to read	4	4	4	100	VV

No.	Aspects Assessed	Score			Average (%)	C
		V1	V2	V3		
	b. The layout of features, images, supporting decorations, and text is proportional	4	4	4	100	VV
	c. The design of each page is attractive and not excessive	4	4	4	100	VV
	d. Page numbers are neatly arranged and consistent	4	4	4	100	VV
4.	**Image Quality**					
	a. Images are relevant to the topic	4	4	4	100	VV
	b. Images are clear	4	4	3	91,67	VV
Average Presentasion Aspects (%)					**98,33**	**VV**
B. Content						
1.	**E-LKPD Component Completeness**					
	a. Introduction containing the main cover, preface, table of contents, instructions for using E-LKPD, description of E-LKPD features, Project Based Learning syntax, ecosystem material concept map, learning objectives, and learning outcomes	4	4	4	100	VV
	b. Main content section containing student activities in developing problem-solving skills and features (B-Think, B-Insight, B-Project, B-Schedule, B-LogBook, B-Tasks, and B-Feedback)	4	4	4	100	VV
	c. Closing section containing a post-test and reference list	4	4	4	100	VV
2.	**Preface**					
	a. Contains an overview of the contents of the E-LKPD	4	4	4	100	VV
	b. Contains a request for criticism and suggestions for improvement of the E-LKPD	4	4	4	100	VV
3.	**Instruction for Use**					
	a. Use clear (unambiguous) words	4	4	4	100	VV
	b. Include information that E-LKPD has various features that can be accessed online	4	4	4	100	VV
4.	**Quality of Material Concepts**					
	a. The ecosystem material presented is taken from valid sources	3	4	4	91,67	VV
	b. The scope and depth of content form an accurate understanding of concepts	4	4	4	100	VV
	c. The ecosystem material, especially ecosystem balance in E-LKPD, is systematic and easy to understand	3	4	3	83,33	VV
	d. There are additional images, videos, and research journals that support the ecosystem material in accordance with the concepts	3	4	3	83,33	VV
	e. The ecosystem material presented is in accordance with the learning objectives	4	4	4	100	VV
5.	**Ecosystem Material Completeness**					
	a. Includes an introduction to the material	4	4	4	100	VV
	b. Includes a definition of ecosystem balance	4	4	4	100	VV
	c. Includes the impact of ecosystem balance on the surrounding environment	4	4	4	100	VV
	d. Includes solutions to the impact of ecosystem imbalance	4	4	4	100	VV
	e. Includes hyperlinks for additional information on solutions to the impact of ecosystem imbalance	4	4	4	100	VV
C. Syntactic Consistency of the Project Based Learning Model						
1.	**Determining Fundamental Question**					
	a. Readings and images can stimulate students in answering trigger questions	3	4	4	91,67	VV
	b. There are readings that provide	4	4	4	100	VV

No.	Aspects Assessed	Score			Average (%)	C
		V1	V2	V3		
	information and instructions for students regarding the E-LKPD activities that will be carried out in the B-Think feature					
2.	**Design a Plan for The Project**					
	a. There are instructions that guide students to design a project (B-Project)	4	4	4	100	VV
	b. There are guidelines that help students design a project (B-Project)	4	4	4	100	VV
3.	**Create a Schedule**					
	a. There are instructions that direct students to create a project schedule (B-Schedule)	4	4	4	100	VV
	b. There are guidelines that help students create a project schedule (B-Schedule)	4	4	4	100	VV
4.	**Monitoring Student Work and Project Progress**					
	a. There are instructions directing students to create project progress reports (B-LogBook)	4	4	4	100	VV
	b. There are guidelines to help students create project progress reports (B-LogBook)	4	4	4	100	VV
5.	**Assessing Results**					
	a. There are instructions directing students to create product presentation media (B-Tasks)	3	4	4	91,67	VV
	b. There are guidelines to help students create posters for product presentations (B-Tasks)	4	4	4	100	VV
6.	**Evaluating Experience**					
	a. There are instructions that direct students to evaluate the knowledge they have acquired (B-Tasks and B-Feedback)	4	4	4	100	VV
	b. There are guidelines that help students evaluate the knowledge they have acquired (B-Tasks and B-Feedback)	4	4	4	100	VV
D. Achievement of Problem-Solving Skills						
1.	**Alignment of E-LKPD with Problem-Solving Skills**					
	a. E-LKPD trains students in problem analysis skills	3	4	4	91,67	VV
	b. E-LKPD trains students in strategy development skills	4	4	4	100	VV
	c. E-LKPD trains students in strategy implementation skills	4	4	4	100	VV
	d. E-LKPD trains students in reviewing results skills	4	4	4	100	VV
2.	**Achievement of Problem-Solving Skills Using Project-Based Learning Steps**					
	a. Determining Fundamental Questions step achieves the indicator of analyzing problems	4	4	4	100	VV
	b. Design Plan for Project step achieves the indicator of developing strategies	3	4	4	91,67	VV
	c. Create a Schedules step achieves the indicator of developing strategies	4	4	4	100	VV
	d. Monitoring Student Work and Project Progress step achieves the indicator of implementing strategies	4	4	4	100	VV
	e. Conducting Work Assessment Achieves the Indicator of Reviewing Results	4	4	4	100	VV
	f. Evaluating the Experience Achieves the Indicator of Reviewing Results	4	4	4	100	VV
Average Content Aspects (%)					**98,08**	**VV**
E. Language						
1.	**Use of Language**					
	a. The language used is proper and correct Indonesian	4	4	4	100	VV
	b. The language used is easy to understand	4	4	4	100	VV
	c. The language used is straightforward	4	4	4	100	VV
	d. The language used is communicative	4	4	4	100	VV

No.	Aspects Assessed	Score			Average (%)	C
		V1	V2	V3		
2.	**Use of Words**					
	a. Appropriate use of vocabulary	4	4	4	100	VV
	b. Choice of vocabulary that is easy to understand	4	4	4	100	VV
Average Language Aspects (%)					100	**VV**
Overall Average (%)					**98,80**	**VV**

Keterangan:
V1: Media Expert C : Criteria
V2: Subject Matter Expert VV : Very Valid
V3: High School Biology Teacher

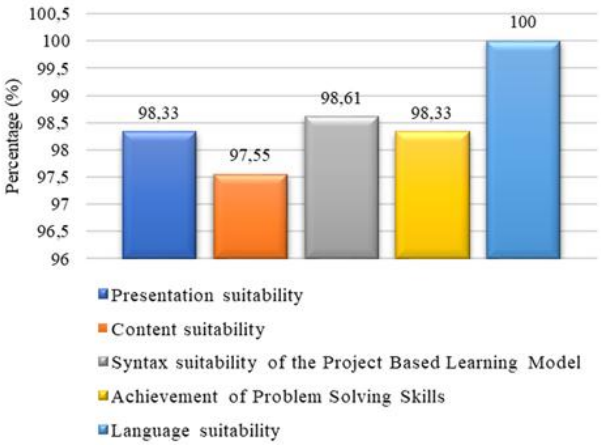

Figure 1. E-LKPD Validation Results Chart

The E-LKPD assessment was deemed highly valid in accordance with the indicators and eligibility requirements. Based on the data in Table 1, which shows that the validity score was based on three aspects, namely presentation, content, and language. The presentation aspect received a score of 98.33% (highly valid), which includes the use of E-LKPD, the quality of the cover, the quality of the layout, and the quality of presentation support. The content aspect received a score of 98.08% (highly valid), which includes the components of E-LKPD, the syntax conformity of the PjBL model, and the achievement of problem-solving skills. The language aspect scored 100% (highly valid), which includes the use of proper and correct language and words. Overall, the score was 98.80%, categorized as highly valid according to Riduwan's (2016) interpretation in the range of 88%–100%. This validity test was used to assess the level of suitability or validity of the product based on presentation aspects, content components (compliance with PjBL syntax and achievement of problem-solving indicators), and language aspects. Based on the validity assessment results, the developed E-LKPD has been declared valid and suitable for pilot testing to achieve the research objectives (Karomah, 2025).

Effectiveness of E-LKPD Based on Project Based Learning

The effectiveness of the developed E-LKPD was measured through the cognitive learning outcomes of students after participating in learning using this media. This assessment was carried out by comparing the results of the pre-test and post-test given before and after learning. The number of questions in the pre-test and post-test was 8 multiple-choice questions and 4 essay questions. The questions were designed based on problem-solving skill indicators, namely analyzing problems, planning strategies, implementing strategies, and reviewing results. Each problem-solving indicator consists of three questions, namely two multiple-choice questions and one essay question (Table 3).

Table 3. Comparison of Pre-test and Post-test Scores

Student Number	Pre-test		Post-test		N-Gain	Category
	Score	Note	Score	Note		
1	50	L	90	VH	0,80	High
2	40	VL	80	H	0,67	Moderate
3	45	VL	90	VH	0,82	High
4	50	L	80	H	0,60	Moderate
5	50	L	80	H	0,60	Moderate
6	55	L	95	VH	0,89	High
7	55	L	90	VH	0,78	High
8	55	L	90	VH	0,78	High
9	40	VL	85	H	0,75	High
10	55	L	90	VH	0,78	High
11	55	L	95	VH	0,89	High
12	55	L	95	VH	0,89	High
13	55	L	95	VH	0,89	High
14	45	VL	85	H	0,73	High
15	55	L	80	H	0,56	Moderate
16	55	L	90	VH	0,78	High
17	55	L	90	VH	0,78	High
18	55	L	80	H	0,56	Moderate
19	55	L	90	VH	0,78	High
20	45	VL	90	VH	0,82	High
Rata-rata	**51,25**	**L**	**88**	**VH**	**0,76**	**High**

Note:
Interpretation of Completiom:
88% – 100% : Very High (VH)
75% – 87% : High (H)
62% – 74% : Moderate (M)
49% – 61% : Low (L)
0% – 48% : Very Low (VL)

Interpretation of N-Gain Calculations:

$0{,}70 \leq g \leq 1{,}00$	: High
$0{,}30 \leq g < 0{,}70$	: Moderate
$0{,}00 < g < 0{,}30$	: Low
$g = 0{,}00$	: No Increase
$-1{,}00 \leq g < 0{,}00$	: Decrease

Based on the data in Table 3, the scores obtained in the pre-test tended to be incomplete, and some students even failed with the lowest score of 40, with an overall average of 51.25, which is classified as low, and a completion rate of 0%. There was an increase in scores on the post-test results, showing a tendency toward high scores in the high and very high categories. The post-test assessment yielded an overall average of 88 in the very high category and a completion rate of 100%. Student achievement in cognitive learning outcomes also referred to the school's minimum competency standard (KKM) of 75. Thus, overall in the post-test assessment, the lowest score was 80 and the highest was 95, with all students achieving the KKM of 75 (Figure 2).

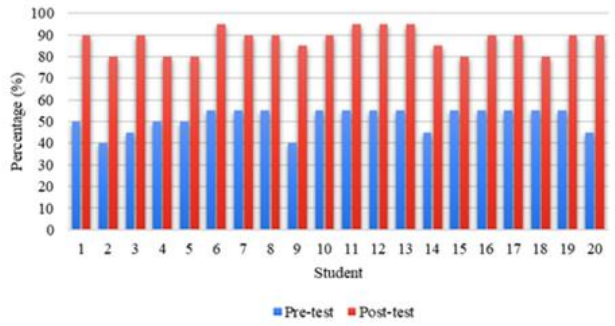

Figure 2. Graph of Pre-test and Post-test Results

Further analysis of effectiveness was conducted through the calculation of Normalized Gain (N-Gain), which yielded an average of 0.76, falling into the high category. This N-Gain value indicates that the improvement in students' cognitive learning outcomes after learning using E-LKPD was at an optimal level. Out of the total 20 students, 15 (75%) achieved the high N-Gain category, while 5 (25%) were in the moderate category. The differences in score improvements among students were due to their varying abilities in understanding and elaborating their answers. Although all students participated well in the learning activities using E-LKPD in accordance with the PjBL syntax and problem-solving skill indicators, there were differences in N-Gain between the pre-test and post-test scores. The differences in the increase in scores among students were due to each student's ability to understand and elaborate on different answers. Some students were not able to elaborate or explain their answers concretely in the post-test questions, so the scores or grades obtained were not optimal. However, overall, there were no students who fell into the low N-Gain category, indicating that this learning media was effectively applied evenly to all students.

Student mastery of cognitive learning outcomes also refers to the school's minimum passing grade of 75. Thus, overall in the post-test assessment, the lowest score was 80 and the highest was 95, with all students achieving the minimum competency standard of 75. The post-test assessment results showed a significant improvement compared to the pre-test, indicating that the use of E-LKPD contributed positively to students' conceptual understanding and problem-solving skills. The high N-Gain increase and the achievement of the problem-solving indicator can be stated that E-LKPD is effective in learning. This means that E-LKPD has an influence in training problem-solving skills and its use can be continued. This effectiveness is inseparable from the Project-Based Learning approach applied in E-LKPD, which provides opportunities for students to be actively involved in the learning process through contextual problem solving, independent exploration, and collaboration in project completion. This media not only helps students understand the material in depth but also trains problem-solving skills that are important in facing learning challenges in the modern era.

Conclusion

The development of PjBL-based E-LKPD on the ecosystem to train problem-solving skills of 10th grade high school students has been proven valid in terms of presentation, content, and discussion, with a rating of highly valid, as well as effective in terms of cognitive learning outcomes with a rating of very good for learning activities.

Suggestion

This study needs further optimization, taking into account the estimated learning time and project activities of students, especially in the production of liquid organic fertilizer, which requires a long time. The use of alternative microorganisms can accelerate the fermentation process. Then, additional activities can be added to train students' problem-solving skills so that they not only become capable but also skilled in meeting 21st-century skills.

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