



THE VALIDITY OF AN INTEGRATED E-LKPD DESIGN FOR RENEWABLE ENERGY, COMBINING PROBLEM-BASED LEARNING AND LOCAL WISDOM, USING CANVA AI TO FACILITATE STUDENTS' CREATIVE THINKING SKILLS

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Received: 29 06 2026. Accepted: 25 07 2026. Published: 07 2026

Abstrak

Penelitian ini bertujuan untuk mengembangkan dan mengevaluasi kelayakan E-LKPD (Lembar Kerja Peserta Didik Elektronik) bertema energi terbarukan yang mengintegrasikan model Problem Based Learning (PBL), unsur kearifan lokal, dan pemanfaatan Canva AI untuk memfasilitasi keterampilan berpikir kreatif peserta didik. Penelitian ini menggunakan pendekatan Research and Development (R&D) dengan model pengembangan 4-D yang meliputi tahap define, design, develop, dan disseminate. Pelaksanaan penelitian dibatasi hingga tahap validasi ahli (expert appraisal) pada fase develop, tanpa melanjutkan ke tahap uji coba produk maupun penyebarluasan, karena penelitian ini berfokus pada pengujian validitas rancangan E-LKPD. Validasi dilakukan oleh tiga ahli yang memiliki kompetensi pada bidang desain pembelajaran, media pembelajaran digital, dan materi fisika. Penilaian mencakup tujuh aspek, yaitu substansi materi, desain visual dan komunikasi, desain pembelajaran, pemanfaatan Canva AI, implementasi PBL, integrasi kearifan lokal, dan kontribusi terhadap keterampilan berpikir kreatif. Hasil analisis menggunakan indeks Aiken's V menunjukkan bahwa E-LKPD yang dikembangkan berada pada kategori sangat valid pada seluruh aspek yang dinilai, dengan nilai rata-rata berkisar antara 0,84–0,90. Kebaruan penelitian ini terletak pada integrasi model PBL, kearifan lokal, dan teknologi Canva AI ke dalam satu media pembelajaran digital untuk memfasilitasi keterampilan berpikir kreatif peserta didik. Dengan demikian, E-LKPD yang dikembangkan layak digunakan sebagai bahan ajar fisika yang mendukung pembelajaran abad ke-21 serta menjadi alternatif inovatif dalam pengembangan media pembelajaran fisika yang kontekstual dan berbasis kearifan lokal.

Kata kunci : Energi Terbarukan, E-LKPD, pembelajaran berbasis masalah, Kearifan lokal, keterampilan berpikir kreatif

Abstract

This study aimed to develop and evaluate the validity of a renewable energy-themed electronic student worksheet (E-LKPD) integrating the Problem-Based Learning (PBL) model, local wisdom, and Canva AI to facilitate students' creative thinking skills. The study employed a Research and Development (R&D) approach using the 4-D development model, consisting of the define, design, develop, and disseminate stages. However, the research was limited to the expert appraisal stage to evaluate the validity of the developed product. The E-LKPD was validated by three experts in physics education, instructional design, and digital learning media using an instrument covering seven aspects: material content, visual and communication design, learning design, Canva AI utilization, PBL implementation, local wisdom integration, and support for creative thinking skills. The validation results, analyzed using Aiken's V index, indicated that the developed E-LKPD achieved a very high level of validity across all assessed

aspects, with average scores ranging from 0.84 to 0.90. The novelty of this study lies in integrating Problem-Based Learning, local wisdom, and Canva AI into a single digital learning resource specifically designed to enhance students' creative thinking skills in renewable energy learning. Therefore, the developed E-LKPD is considered suitable as an innovative physics learning resource that supports 21st-century learning and promotes contextual, local wisdom-based instruction.

Keywords : Renewable Energy, E-LKPD, Problem-Based Learning, Local Wisdom, Creative Thinking Skills.

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INTRODUCTION

The demands of 21st-century learning require students to possess 4C competencies, with creative thinking ability standing out as one of the most highlighted aspects. This ability refers to the capacity to generate varied, original, flexible, and elaborate ideas or solutions in addressing a problem (Hidayat et al., 2023).

Physics is regarded as a field of study with the potential to foster creativity, as it is closely related to natural phenomena in everyday life. Unfortunately, the practice of physics learning in the field is still dominated by a teacher-centered approach, which results in students being less active in the learning process (Kristanti et al., 2012).

On the other hand, the curriculum demands learning that is oriented toward 21st-century skills and cognitive flexibility (Asrizal, 2020; Li et al., 2025). These demands encourage the implementation of a more student-centered approach so that students are able to construct their own understanding through exploration and problem-solving activities (Rahman et al., 2023; Sukaesih et al., 2022).

The use of teaching materials also plays an important role in supporting the success of the learning process (Sriyati et al., 2019). Student worksheets (LKPD) are now being transformed into electronic form (E-LKPD), which is more attractive and practical to access (Yanti et al., 2024), and have proven capable of boosting motivation and

facilitating the understanding of abstract concepts. The validity of E-LKPD will be further enhanced when combined with the Problem Based Learning (PBL) model, which uses real-world problems as the starting point of learning (Qanitah et al., 2022) as well as when integrated with local wisdom to make learning more meaningful (Kasmiati et al., 2021).

The results of a preliminary study at a public senior high school (SMA Negeri) in Padang revealed that the creative thinking ability of tenth-grade students was relatively low, with an average achievement of only 34.29%, particularly on the elaboration indicator, which reached only 31.43%—a finding consistent with the research of (Muhamad et al., 2025). The teaching materials used so far have been limited to textbooks and conventional printed LKPD, without any connection to local wisdom in the renewable energy topic. In fact, this topic greatly requires creativity to analyze various alternative energy sources while also designing solutions to environmental issues (Amaliyah et al., 2023). Most students also reported preferring teaching materials in the form of E-LKPD, as they are considered more contextual and interactive.

Several previous studies have developed E-LKPD based on either PBL or local wisdom separately (Qanitah et al., 2022). developed a PBL-based E-LKPD to foster creative thinking ability, but had not yet integrated elements of local wisdom or the

use of artificial intelligence into the development process. On the other hand, (Rahayu, Sri, et al., 2024) developed a Project Based Learning-based E-LKPD to enhance critical thinking ability, but had not targeted creative thinking ability or measured the validity of the local wisdom component separately. Meanwhile, (Salsabilla et al., 2024) developed a STEM-based E-LKPD on the topic of renewable energy, but without utilizing artificial intelligence technology in its design process.

This gap indicates that no study has yet combined all three elements simultaneously, namely PBL as a framework for addressing real-world problems, local wisdom as a bridge between physics concepts and the surrounding environment, and Canva AI as an artificial intelligence-based tool that accelerates and simplifies the process of creating digital teaching materials (Prabowo & Adillah, 2025). The novelty of this study lies in combining these three elements into a single E-LKPD product specifically designed to facilitate students' creative thinking ability on the topic of renewable energy. This research is directed toward testing the validity of a renewable energy E-LKPD that integrates PBL, local wisdom, and Canva AI to support students' creative thinking ability, by assessing aspects of content feasibility, visual display, practicality of use, and its impact on the development of creativity on the topic of renewable energy.

METHODS

This study uses the Research and Development (R&D) approach as described by (Sugiyono, 2016). In the field of education, this approach primarily aims to produce a product that can be used directly, rather than to formulate or test theory. The development model applied is the 4-D model from (Thiagarajan et al., 1974), which comprises

four stages: define, design, develop, and disseminate. This model was chosen because it remains relevant and has been widely adopted in research on the development of physics teaching materials based on E-LKPD in recent years, given its systematic, simple, and easily adaptable workflow for various learning contexts (Tunga et al., 2021).

This model was chosen because its workflow is structured, simple, easy to understand, and can be implemented systematically; in addition, this model is also commonly used in the development of teaching materials. Validity assessment was carried out by three lecturers from the Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, hereinafter referred to as Validator 1, Validator 2, and Validator 3. The three were selected purposively based on complementary expertise in instructional design, digital learning media, and physics content, so that all seven E-LKPD assessment components could be evaluated thoroughly and comprehensively. The study was conducted in May 2026 at the Department of Physics, FMIPA, Universitas Negeri Padang, given the availability of competent experts to serve as assessors. The activities followed the stages of the 4-D model, limited to the development stage, with the following details:

1. Define Stage Includes analysis of initial conditions, student characteristics, learning needs, the concept of renewable energy material, as well as the formulation of learning objectives.
2. Design Stage Includes determining the form of the teaching material as an E-LKPD that integrates the PBL model and local wisdom, preparing the presentation format, and developing a content framework covering usage instructions,

achievement indicators, and the design of learning activities in line with the PBL syntax and the environmental context.

3. Develop Stage Includes the creation of the E-LKPD using Canva AI, feasibility assessment by three experts, and product revision based on the suggestions provided. The instrument used was a validation sheet developed with reference to the guidelines for developing ICT-based teaching materials . This instrument assesses seven components, namely:
 1. Material substance
 2. Visual display and communication
 3. Instructional design
 4. Utilization of Canva AI
 5. Implementation of the PBL model
 6. Integration of local wisdom
 7. Support for creative thinking ability

Data Analysis Technique Each statement in the assessment sheet uses a scale of 1 to 4, with criteria as shown in Table 1. The data were processed using validator indicator categories to determine the product's feasibility level. The details of these four categories are presented in Table 1.

Table 1.Validator Choice Category

Percentage (%)	Category
76-100	Strongly agree
51-75	Agree
26-50	Disagree
0-25	Strongly disagree

Source: modified (Sugiyono, 2016)

The validity assessment of each statement evaluated was then analyzed using the item validity index, Aiken's V index (V), formulated as follows:

$$V = \frac{\sum s}{n(c - 1)}$$

$$s = r - l$$

$$s = r - L_0$$

Where:

V = Aiken's V validation index

r = the score given by the validator

L_0 = the lowest possible rating

n = the number of raters

c = the number of categories the rater can choose from

Based on Equation 1, r represents the score given by the validator, with the lowest validity score being 1 and the highest validity score being 4, while n indicates the number of validators involved. The categories used to determine the validity level of the E-LKPD are as follows:

Table 2. Aiken's Index Category

Index range	Category
$V \leq 0,4$	Less valid
$0,4 \leq V \leq 0,8$	Valid
$0,8 \leq V$	Verry valid

Sumber: (Retnawati, 2016)

RESULTS AND DISCUSSION

The first component validated was material substance. The validity test results of the E-LKPD on Renewable Energy Integrated with PBL and Local Wisdom using Canva AI show that the material substance component consists of four indicators: accuracy, scope of material, currency, and readability. To ensure that the material presented is consistent with physics concepts, relevant to advances in science, and easily understood by students, each indicator was assessed. The results of the analysis for each indicator of the material substance component are presented in Table 3.

Table 3. Results of the Material Substance Component Analysis

Assessment Indicator	Average	Description
Accuracy	0,96	Verry valid
Material Scope	0,90	Verry valid
Currency	0,77	Valid
Readability	0,91	Verry valid
Overall Average	0,88	Verry valid

Based on the data presented in Table 3, the analysis results for the material substance component ranged from 0.77 to 0.96, placing it in the valid to very valid category. The material presented was consistent with correct physics concepts and principles, as indicated by the accuracy indicator, which obtained the highest score of 0.96. The material scope indicator obtained a score of 0.90, indicating that the renewable energy material had been adequately presented in accordance with the learning outcomes, while the readability indicator obtained a score of 0.91, indicating that the language and presentation of the material were easily understood by students.

Meanwhile, the indicator with the lowest score in this component was currency, at 0.77. Although still falling within the valid category, this score was relatively lower than the other three indicators. This low score indicates that in the initial draft, the material presented was still more focused on the basic concepts of renewable energy, while its connection to technological developments and current issues in the field had not been fully explored. This finding served as the basis for product improvement, namely by adding more up-to-date data, examples, and illustrations of renewable energy applications, so that the material would not only be conceptually accurate but also relevant to current developments in science and technology. Following this improvement, the overall average score for the material substance component reached 0.88, placing it in the very valid category. Therefore, the material in the E-LKPD on Renewable Energy Integrated with Problem Based Learning and Local Wisdom using Canva AI is considered feasible for use in learning, as it is able to support a learning process that facilitates students' creative thinking skills.

Visual communication, the results of the second component's validation, is used to convey information to users through visuals that are attractive and easy to understand. Four indicators are included in the visual communication component: font, navigation, color, and layout. Table 4 shows the analysis results for each indicator of the visual communication component.

Table 4. Results of the Visual Communication Display Component Analysis

Assessment Indicator	Average	Description
Font	0,77	Valid
Navigation	0,83	Verry valid
Color	1	Verry valid
Layout	1	Verry valid
Overall Average	0,90	Verry valid

Based on the data in Table 4, the analysis results for the visual communication component fall into the very valid category, with scores ranging from 0.77–1. The type and size of the font used were appropriate and easy for students to read, as indicated by the font indicator, which obtained a score of 0.77. The navigation indicator obtained a score of 0.83, indicating that moving between sections within the E-LKPD was easy to use; the color and layout indicators each obtained a score of 1.00, indicating that the color combinations and arrangement of elements in the E-LKPD were attractive, consistent, and supportive of comfortable learning; and the overall average indicator obtained a score of 0.90, indicating the very valid category. Therefore, it was determined that the visual communication elements of the E-LKPD on Renewable Energy Integrated with Problem Based Learning and Local Wisdom using Canva AI are feasible for use in learning.

The results of the third component's validation show that the instructional design aims to support the valid transfer of

knowledge to students. The instructional design component consists of the following indicators: title, learning outcomes, learning objectives, material, learning instructions, learning steps, student activities, exercises, references, and author identity. Table 5 shows the analysis results for each indicator of the instructional design component.

Table 5. Results of the Instructional Design Component Analysis

Assessment Indicator	Average	Description
Title	1	Verry valid
Learning Outcomes	0,88	Verry valid
Learning Objectives	0,88	Verry valid
Material	0,77	Valid
Learning Instructions	1	Verry valid
Learning Steps	0,77	Valid
Student Activities	0,88	Verry valid
Exercises	0,88	Verry valid
References	1	Verry valid
Author Identity	1	Verry valid
Overall Average	0,90	Verry valid

The data in Table 5 show that the instructional design component falls into the very valid category, with scores ranging from 0.77–1. A score of 1.00 was obtained for the title, learning instructions, references, and author identity indicators, indicating that these four components were presented very well and completely. Meanwhile, the learning outcomes, learning objectives, student activities, and exercises indicators obtained a score of 0.88, indicating the suitability of these components with the intended learning objectives. The material and learning steps indicators obtained a score of 0.77, which also indicates a very good presentation. Overall, the average score obtained was 0.90, falling into the very valid category. Thus, the instructional design of the E-LKPD on Renewable Energy that integrates problem-based learning and local wisdom through

Canva AI is considered feasible for use in the learning process.

Next, the validation of the fourth component was carried out on the utilization of Canva AI in the development of the E-LKPD, which consists of four indicators, namely interactivity, primary software, supporting software, and originality. The analysis results for each indicator in this component are presented in Table 6.

Table 6. Results of the Software Utilization Component Analysis

Assessment Indicator	Average	Description
Interactivity	0,92	Verry valid
Primary Software	0,83	Verry valid
Supporting Software	0,77	Valid
Originality	0,88	Verry valid
Overall Average	0,85	Verry valid

The data in Table 6 show that the Canva AI utilization component obtained scores ranging from 0.77 to 0.92, with validity categories ranging from valid to very valid. The highest score was obtained for the interactivity indicator, at 0.92, indicating that the E-LKPD successfully delivered an engaging and interactive learning experience for students. The primary software indicator obtained a score of 0.83, signifying that Canva AI had been optimally utilized in the process of developing the teaching material. Meanwhile, the supporting software indicator obtained a score of 0.77, falling into the valid category, indicating that the additional tools used had functioned well in supporting the presentation of the material. The originality indicator obtained a score of 0.88, demonstrating that the developed product possesses creative and novel value. Overall, the average score obtained was 0.85, falling into the very valid category. Thus, the application of Canva AI in the development of

this E-LKPD is considered feasible and suitable for use in learning activities.

Validation of the fifth component was aimed at assessing the integration of the Problem Based Learning (PBL) model within the E-LKPD content. This component was measured through five indicators, namely providing problem orientation, organizing students, providing guidance in the investigation process, developing and presenting work results, and analyzing and evaluating the problem-solving process. The detailed assessment results for each of these indicators are presented in Table 7.

Table 7. Results of the Learning Model Integration Component Analysis

Assessment Indicator	Average	Description
Problem Orientation	0,88	Verry valid
Organizing Students	0,88	Verry valid
Guiding Investigation	0,88	Verry valid
Developing and Presenting Results	0,88	Verry valid
Analyzing and Evaluating	0,66	Valid
Overall Average	0,84	Verry valid

The data in Table 7 show that the analysis results for the integration of the Problem-Based Learning model ranged from 0.66 to 0.88, falling into the valid to very valid category. A score of 0.88 was obtained for the problem orientation, organizing students, and developing and presenting results indicators, indicating that the stages of PBL had been well integrated into the E-LKPD. The guiding investigation indicator obtained a score of 0.88, indicating that students had been facilitated to carry out an investigation process in solving problems. Meanwhile, the analyzing and evaluating indicator obtained a score of 0.66, falling into the valid category, indicating that this aspect still has room for improvement. Overall, the average score obtained was 0.84, falling into the very valid category. Thus, the integration of the Problem

Based Learning model in this E-LKPD is considered feasible for use in learning.

The results of the validation of the sixth component concern the integration of local wisdom into the E-LKPD. This component covers four indicators, namely the appropriateness of local wisdom, clarity of presentation, relevance of local wisdom, and contextuality of local wisdom. The analysis results for each indicator of the local wisdom component can be seen in Table 8.

Table 8. Results of the Local Wisdom Integration Component Analysis

Assessment Indicator	Average	Description
Appropriateness	0,88	Verry valid
Clarity of Presentation	0,88	Verry valid
Relevance	0,88	Verry valid
Contextuality	0,77	Valid
Overall Average	0,86	Verry valid

Based on the data presented in Table 8, the analysis results for the local wisdom component show scores ranging from 0.77 to 0.88, falling into the valid to very valid category. The appropriateness indicator of the local wisdom elements obtained a score of 0.88, meaning that the cultural values incorporated were suitable and aligned with the material on renewable energy. Furthermore, the clarity of presentation and relevance of local wisdom indicators each reached a score of 0.88, indicating that the cultural material was conveyed clearly and closely related to students' everyday reality and experience. Meanwhile, the contextuality indicator obtained a score of 0.77, indicating that the examples of local wisdom used were appropriate to students' living environment. Overall, the average score obtained was 0.86, falling into the very valid category. This demonstrates that the integration of local wisdom elements into the E-LKPD is

appropriate and feasible for application in the learning process.

The seventh component in this validity assessment evaluates the integration of creative thinking skill aspects, measured through four indicators, namely fluency, flexibility, originality, and elaboration. The detailed calculation and assessment results for each of these indicators are presented in Table 9.

Table 9. Results of the Creative Thinking Ability Integration Component Analysis

Assessment Indicator	Average	Description
Fluency	1	Very valid
Flexibility	0,77	Valid
Originality	0,88	Very valid
Elaboration	0,77	Valid
Overall Average	0,86	Very valid

Based on the data in Table 9, the scores for the creative thinking skills component ranged from 0.77 to 1.00, falling into the very valid category with an average score of 0.86. The fluency indicator achieved the highest score, at 1.00, followed by originality at 0.88, and elaboration at 0.77, while flexibility ranked lowest, with a score of 0.77. Based on these results, the E-LKPD themed around renewable energy, developed using the problem-based learning model, local wisdom, and Canva AI technology, is considered feasible for use.

All assessment aspects fell into the very valid category, with the following average scores: material content (0.88), visual display (0.90), instructional design (0.90), application of Canva AI (0.85), integration of the PBL model (0.84), local wisdom elements (0.86), and creative thinking ability (0.86). These figures demonstrate that the product is suitable for use in physics learning while also being able to train students' creative thinking ability.

On the material substance aspect, an average score of 0.88 was obtained, with the concept accuracy indicator reaching 0.96 — a figure higher than that reported in the study by (Qanitah et al., 2022). However, the material currency indicator obtained a score of only 0.77; this was because the preparation of the initial draft focused more on presenting basic concepts to make them easy for students to understand, so information on technological developments and the latest applications was still limited. Therefore, the material was updated by adding data and examples of the most recent applications of renewable energy to make it more relevant to advances in science. For the visual display aspect, the average score reached 0.90, with the color selection and layout obtaining a perfect score of 1.00. This result is consistent with, and even superior to, the study by (Gulo et al., 2024) although the font type and size indicator obtained a score of only 0.77, as the initial format was not well suited for mobile screens; improvements were therefore made by changing the font type and adjusting its size to make it easier to read in digital form.

The application of the PBL model obtained an average score of 0.84. The problem orientation, student organization, and results presentation indicators obtained high scores of 0.88, indicating that the stages of this model had been well implemented. In contrast, the analyzing and evaluating problem-solving process indicator had the lowest score, at 0.66; this occurred because the initial draft had not yet included detailed assessment guidelines and reflection sheets, which were subsequently supplemented with process assessment criteria and self-development questions. In contrast to the study by (Salsabilla et al., 2024), This E-LKPD not only has the potential to develop critical thinking ability but also creative

thinking skills through the integration of a more comprehensive PBL syntax. The local wisdom integration component obtained an average score of 0.86, indicating that cultural elements had been presented clearly, relevantly, and contextually in relation to students' environment and lives. This finding constitutes a new contribution, as it differs from the study by (Rahayu, Ovita, et al., 2024) which had not yet measured the validity of the local wisdom aspect separately. Furthermore, the creative thinking skills component also obtained an average of 0.86, with the fluency indicator reaching a perfect score of 1.00 and originality at 0.88. However, the flexibility indicator remained relatively low at 0.77; this was because the tasks in the initial version were still structured and had limited answers, which was subsequently addressed by designing more open-ended questions and activities to encourage students to view problems from various perspectives. This finding is relevant to a 2024 report stating that the creative thinking ability of students in Indonesia is still relatively low.

Beyond providing quantitative assessments, the three validators also offered qualitative notes as a basis for product improvement. The input from each validator is presented in Table 10.

Tabel 10. Validators' Suggestions

Validator	Suggestions
1	(1) Break down the 5th PBL syntax into several questions (2) Use more detailed questions in the 5th PBL syntax.
2	(1) Supporting material was not yet complete (2) Tasks, exercises, and evaluations were not yet available (3) The problem to be solved was still superficial and had not been presented in narrative form.
3	(1) Change the title color and make it bold (2) Revise sentences to match the

context/indicators

- (3) End every instructional sentence with an exclamation mark (!)
(4) Check for typographical errors (typos).

All three validators stated that the revisions were adequate and that the E-LKPD was feasible for use in physics learning. Overall, this study contributes by combining renewable energy material, the PBL model, local wisdom, and Canva AI technology into a single, unified E-LKPD product. The validity scores, ranging from 0.84 to 0.90, indicate a product quality equal to or even better than similar teaching materials based on PBL, PjBL, or STEM. The main novelty of this study lies in the utilization of Canva AI and the separate measurement of the validity of the local wisdom component and creative thinking skills. Nevertheless, after improvements were made to the aspects of material currency, text readability, completeness of learning evaluation, and activities that train flexibility of thinking, the resulting final E-LKPD is considered feasible for use and has the potential to facilitate the improvement of students' creative thinking skills.

SIMPULAN

This study produced a Renewable Energy E-LKPD that integrates the Problem Based Learning model, elements of local wisdom, and Canva AI technology to facilitate the development of students' creative thinking skills. Based on the expert validation results using Aiken's V index, the developed product obtained average scores ranging from 0.84 to 0.90 and was categorized as very valid across all assessment components. This confirms that the E-LKPD meets the feasibility requirements in terms of material substance, visual display, instructional design, and the integration of the learning elements used. The presentation of real-world problems and the

surrounding environmental context helps students understand the concept of renewable energy more meaningfully and has the potential to encourage the emergence of creative ideas in problem-solving. The novelty of this study lies in the combination of the learning model, local wisdom, and technology into a single, unified digital teaching material that supports 21st-century physics learning.

Practically, these validation results indicate that the E-LKPD can serve as an alternative teaching material for physics teachers, particularly on the topic of renewable energy, to support learning that is more contextual and oriented toward strengthening students' creative thinking in line with the demands of the 21st-century curriculum. Nevertheless, it should be noted that this validity is based solely on expert assessment through the expert appraisal stage, so the E-LKPD can only be declared feasible in terms of design, but cannot yet be said to have been proven practical or effective in improving learning outcomes or students' creative thinking skills directly in the field. Therefore, further research is recommended to conduct practicality testing through the responses of teachers and student users, as well as effectiveness testing through the implementation of the E-LKPD on a wider class or school scale, before this product is generally implemented in physics learning across various educational institutions.

DAFTAR PUSTAKA

- Amaliyah, Supeno, F., Wahyuni, S., & Sri. (2023). The Profile of Junior High School Students ' Creative Thinking Skills about Alternative Energy in Science Learning. 12(1), 18–23.
- Asrizal, F. (2020). Studi Pendampingan Pengembangan Bahan Ajar Tematik Terintegrasi Literasi Baru dan Literasi Bencana Pada Guru IPA Kabupaten Agam. 4.
- Gulo, D. D. S., Laoli, B., & Laoli, E. S. (2024). Pengembangan media pembelajaran video interaktif untuk meningkatkan hasil belajar siswa. 5(2), 314–327.
- Hidayat, R. K., Novianti, B. A., & Subki, S. (2023). Meningkatkan Kemampuan Berpikir Kreatif Fisika Peserta Didik Berbasis Kurikulum Merdeka. Jurnal Ilmiah Profesi Pendidikan, 8(2), 1143–1151.
<https://doi.org/10.29303/jipp.v8i2.1412>
- Kasmianti et al, 2023. (2021). pengertian bahan ajar. 32(3), 167–186.
- Kristanti, dyah yulita, Subiki, & Rif'ati, H. dina. (2012). Model Pembelajaran Berbasis Proyek (Project Based Learning). Pembelajaran Fisika, 5(2), 122–128.
- Li, T., Chen, I., Krajcik, J., & Kelly, S. C. (2025). Designing for and investigating elementary students ' cognitive flexibility , science , and literacy achievement in project-based science learning. 1, 1–23.
- Muhamad, Y., Hanif, R., Maulina, D., & Meriza, N. (2025). Analisis Profil Kemampuan Berpikir Kreatif Siswa pada Materi Pertumbuhan dan Perkembangan Makhluk Hidup. 13(2), 36–45. <https://doi.org/10.23960/jb1325>
- Prabowo, A., & Adillah, R. (2025). Canva Training For Students: Meningkatkan Daya Saing dan Kreativitas Personal Branding pada Era Revolusi Digital. Jurnal Pengabdian UntukMu NegeRI, 9(3), 421–431.
<https://doi.org/10.37859/jpumri.v9i3.10401>

- Qanitah, S., Liska, B., & Lulu, T. B. (2022). Validitas E-LKPD Berbasis PBL Tema Energi dan Makanan dalam Menumbuhkan Kemampuan Berpikir Kreatif Peserta Didik. *Jurnal Pendidikan Mipa*, 12(3), 443–454.
- Rahayu, S. T., Ovita, D., Zahra, A., & Lampung, U. (2024). Development Of Project-Based Learning-Based E- Lkpd To Improve Elementary School Students ' Critical Thinking Skills Pengembangan E-Lkpd Berbasis Project Based Learning Untuk Meningkatkan Kemampuan. 12(2), 131–141.
- Rahayu, Sri, B., Hartinah, Sitti, & Suriswo. (2024). Pengembangan Modul Ajar IPAS dengan Model Pembelajaran Project Based Learning Berbantu AI Canva pada Siswa Sekolah Dasar. *Journal of Education Research*, 5(3), 3883–3887.
<https://doi.org/10.37985/jer.v5i3.1502>
- Rahman, N., Nizaar, M., & Sabaryati, J. (2023). Profil Keterampilan Berpikir Kreatif Mahasiswa dan Upaya Peningkatannya melalui Model Project Based Learning. 6(2), 162–166.
- Retnawati, H. (2016). Proving content validity of self-regulated learning scale (The comparison of Aiken index and expanded Gregory index). *REID (Research and Evaluation in Education)*, 2(2), 155–164.
<https://doi.org/10.21831/reid.v2i2.11029>
- Salsabilla, A., Kaniawati, I., & Liliawati, W. (2024). Development of e-LKPD Based on STEM to Enhance Students ' Critical Thinking Skills on Topic of Renewable Energy. 10(1).
- Sriyati, S., Rimbun, W., & Amprasto. (2019). Improvement Of Creative Thinking By Teaching Materials Based On Local Potential Of Pondok Bali Mangrove. *Edusains*, 11(1), 105–111.
- Sugiyono. (2016). Metode penelitian kuantitatif,kualitatif, dan R&D. 297–313.
- Sukaesih, S., Zubaidah, S., Mahanal, S., & Listyorini, D. (2022). Enhancing students ' nature of science understanding through project-based learning and mind mapping. 11(4), 1704–1713.
<https://doi.org/10.11591/ijere.v11i4.22282>
- Thiagarajan, Semmel, S., Semmel, D. S., & I., M. (1974). *Instructional Development for Training Teachers of Exceptional Children*.
- Tunga, M. F., Sumardi, Y., Hasanah, D., Didik, P., Xii, K., & Sedayu, N. (2021). The Development of Electronic Student Worksheet with Project- Based Learning on Direct Current Circuit Topic for XII Grade of SMA Negeri 1 Sedayu Students Pengembangan E-LKPD Fisika dengan Model Project Based Learning pada Materi Rangkaian Listrik Arus Se. *Jurnal Ilmiah Pendidikan Fisika*.
- Yanti, D., Okmayura, F., & Sisri, E. M. (2024). Penerapan E-LKPD Berbantuan Liveworksheet Pada Materi Daur Biogekimia Kelas X SMA Negeri 01 Pekanbaru. *Katalis Pendidikan: Jurnal Ilmu Pendidikan Dan Matematika*, 1(1), 12–18.