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Validity of E-LKPD Based on Problem Based Learning Using Live Worksheets to Improve Creative Thinking Skills on Renewable Energy Material

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ABSTRACT

This study aims to develop a Problem-Based Learning (PBL)-based Electronic Student Worksheet (E-LKPD) using Live Worksheets on renewable energy topics and to determine its validity. The research uses a Research and Development (R&D) approach with the 4D model (define, design, develop). Data were collected through a validation questionnaire assessed by three experts using the Aiken's V index. The results show an average validity score of 0.93, categorized as very valid, indicating that the product is feasible for use in physics learning. The integration of Live Worksheets also provides interactive digital support that has the potential to enhance students' creative thinking skills. However, this study is limited to the validity stage; therefore, further research is needed to examine its practicality and effectiveness in classroom implementation..

Keywords: E-LKPD, Liveworksheet, Problem Based Learning Model, Creative Thinking.

I. INTRODUCTION

The 21st century is characterized by the rapid growth of science and technology, which has brought significant transformations in various aspects of human life, including education. Advances in information and communication technology (ICT) make information more accessible, easier to understand, and support more efficient interaction in the learning process[1] . In this context, education is required to equip students with essential 21st-century skills, commonly known as the 4Cs: critical thinking, collaboration, communication, and creativity [2]. Among these, creative thinking plays a crucial role, particularly in physics learning, as it enables students to generate ideas, solve problems, and adapt to complex situations [3].

However, students' creative thinking skills are still relatively low. Observations at SMAN 1 Tigo Nagari show that students' creative thinking skills on renewable energy topics have an average score of 35.31. This finding is consistent with previous studies reporting an average achievement of 35.7%, which remains in the low category[4] This condition indicates that current learning practices have not optimally facilitated the development of creative thinking skills, even though these skills are highly needed in the modern workforce [5]. One contributing factor is the limited use of learning models and teaching materials that actively engage students in problem-solving activities [8].

Problem-Based Learning is an approach that can address this issue, as it emphasizes contextual problem-solving and encourages active student participation in constructing knowledge [6]. In its implementation, teachers play an important role in guiding students through each stage of the problem-solving process [7]. However, the effectiveness of Problem-Based Learning depends on the availability of appropriate teaching materials that can support these learning activities. Teaching materials are systematically arranged resources that help teachers and students achieve learning objectives and support independent learning in accordance with the curriculum [9]. With teaching materials, teachers will be more consistent in teaching students and will achieve all predetermined competencies. Teachers have the opportunity to innovate by developing teaching materials that focus on various aspects of learning. One such approach is developing student worksheets. One commonly used form is student worksheets, which are essential tools in facilitating student activities during the learning process.

In practice, the worksheets used in schools are often considered less engaging, ineffective, and unable to optimally support learning, which impacts students' motivation [10]. Along with technological developments,

teaching materials have evolved from printed to digital formats, such as Electronic Student Worksheets. The development of E-LKPD represents an innovation that aligns with the demands of 21st-century learning by integrating technology into the learning process [11]. Online learning in the era of the industrial revolution 4.0 further emphasizes the importance of utilizing digital media in education[12]. One platform that supports this development is Live Worksheets, which allows teachers to convert conventional worksheets into interactive digital formats with automatic feedback features [13].

The integration of Problem-Based Learning into E-LKPD supported by Live Worksheets can enhance learning by presenting contextual problems, guiding investigations, and facilitating the presentation and evaluation of results [14]. In addition, this approach supports the development of creative thinking skills, including fluency, flexibility, originality, and elaboration. Despite Indonesia's vast renewable energy potential, learning on this topic is often still theoretical and does not sufficiently challenge students' thinking skills [15]. Therefore, innovative teaching materials are needed to make learning more meaningful and engaging. However, the integration of PBL-based E-LKPD using Live Worksheets specifically designed to improve students' creative thinking skills on renewable energy topics is still limited. This indicates a gap in the availability of interactive, technology-based teaching materials that effectively combine student-centered learning models with digital platforms.

Based on these considerations, this study aims to develop and assess the validity of a Problem-Based Learning (PBL)-based E-LKPD using Live Worksheets to improve students' creative thinking skills on renewable energy topics. This research is expected to contribute to the development of innovative teaching materials that support 21st-century learning and enhance students' engagement and higher-order thinking skills.

II. METHOD

This study adopts a Research and Development (R&D) approach. According to [16] R&D is a research method used to develop a particular product. In the field of education, it is intended to produce practical products that can be applied in the classroom rather than to develop or test theories. The research design used is the 4D model, which consists of four stages: define, design, develop, and disseminate[17]. In this study, the procedures were adapted to the characteristics of the subjects and development needs, and the implementation was limited to the development stage, particularly focusing on product validity testing. The dissemination stage was not conducted, as the primary objective was to produce a valid product. This model was selected because it is systematic, simple, and commonly used in the development of teaching materials.

The E-LKPD assessment instrument refers to the ICT-Based Teaching Material Development Guidelines [18] and consists of several components. The material substance component includes accuracy, coverage, relevance (currentness), and readability. The learning design component includes title, learning outcomes, objectives, material, exercises, authorship, and references. The visual communication display includes navigation, fonts, media, color, video, and layout. The software utilization component includes interactivity, main software, supporting software, and originality. The integration of the Problem-Based Learning model refers to[19] and includes problem orientation, organizing, guiding investigations, developing and presenting results, and analyzing and evaluating. The integration of creative thinking skills includes fluency, flexibility, originality, and elaboration.

The data were collected through a validation questionnaire developed based on these components[18]. The product was evaluated by three validators who are physics lecturers from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang. The use of three validators is considered adequate in content validity studies, as it allows for expert judgment from relevant academic backgrounds while maintaining consistency and feasibility in evaluation. Each validator assessed the instrument using a four-point scale, as presented in Table 1, to determine the level of product validity.

Table 1. Validator Selection Categories

Categories	**Score**
Strongly Agree (SS)	4
Agree (S)	3
Disagree (TS)	2
Strongly Disagree (STS)	1

(Source: Ref[16])

The validity assessment of each statement assessed was then analyzed using the Aiken's V item validity index, which is formulated as follows:

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

With

$$s = r - L_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Based on Equation 1, Aiken's V measures the level of agreement among validators on item validity. In this formula, r is the score given by each validator, l_0 is the lowest score (1), c is the highest score (4), and n is the number of validators. The criteria for determining the validity level of the E-LKPD are presented in Table 2.

Table 2. Aiken Index Categories

Index range	Category
V≤0,4	Less Valid
0,4≤V≤0,8	Valid
0,8≤V 1	Very Valid

(Source: Ref[20])

III. RESULTS AND DISCUSSION

Results

The results of this study are based on validation scores given by three lecturers from the Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang. The assessment encompassed six components, namely material substance, visual communication, learning design, software utilization, the Problem-Based Learning model, and creative thinking skills. The validation results for the first component are the material substance component. The validity test results of the E-LKPD Based on Problem-Based Learning Using Live Worksheets to Improve Creative Thinking Skills in Renewable Energy Materials in the material substance component consist of four components: 1) accuracy, 2) material coverage, 3) currentity, and 4) readability. The assessment results for each assessment item are converted into a score. The analysis results for each material substance component indicator are shown in Table 3.

Table 3. Results of Analysis of Material Substance Components

Assessment Indicator	Average	Description
Truth	0,94	Very valid
Coverage	0,94	Very valid
Currentness	0,94	Very valid
Readability	0,89	Very valid
Overall Average	0,93	Very valid

Based on the data presented in Table 3, the material substance component shows scores ranging from 0.89 to 0.94, all categorized as very valid. The truth, coverage, and currentness indicators each obtained a score of 0.94, indicating that the material is accurate, comprehensive, and aligned with current developments. The readability indicator scored 0.89, showing that the material is presented in language that is easily understood by students. Overall, the average score of 0.93 falls into the very valid category, indicating that the material substance in the PBL-based E-LKPD using Live Worksheets on renewable energy is feasible and appropriate for use in the learning process.

The validation results for the second component focus on visual communication display, which serves to present information about the Renewable Energy E-LKPD to users through visual elements. This component consists of six indicators: (1) navigation, (2) fonts, (3) media, (4) color, (5) video, and (6) layout. The analysis results for each indicator of the visual communication display component are presented in Table 4.

Table 4. Results of Analysis of Visual Communication Display Components

Assessment Indicator	Average	Description
Navigation	0,94	Very valid
Font	1	Very valid
Media	0,94	Very valid
Color	0,89	Very valid
Video	0,94	Very valid
Layout	0,94	Very valid
Overall average	0,94	Very valid

Based on the data in Table 4, the visual communication display component shows scores ranging from 0.89 to 1.00, all categorized as very valid. The navigation, media, video, and layout indicators each obtained a score of 0.94, indicating a well-structured and user-friendly display. The font indicator achieved the highest score of 1.00, showing that the type and size of the text are highly appropriate and readable. Meanwhile, the color indicator scored 0.89, suggesting that the color selection adequately supports the overall display. Overall, the average score of 0.94 falls into the very valid category, indicating that the visual communication display component in the PBL-based E-LKPD using Live Worksheets is suitable for use in the learning process.

The validation results for the third component demonstrate a learning design that facilitates effective knowledge transfer from the E-LKPD to users. The learning design component encompasses six indicators: 1) title, 2) learning outcomes, 3) learning objectives, 4) materials, 5) exercises, compilers, and 7) references. The analysis results for each learning design indicator are shown in Table 5.

Table 5. Results of Learning Design Component Analysis

Assessment Indicator	Average	Description
Title	1	Very valid
Learning Outcomes	0,94	Very valid
Learning Objectives	0,83	Very valid
Materials	0,89	Very valid
Exercises	0,89	Very valid
Compiler	1	Very valid
References	1	Very valid

Overall Average	0,93	Very valid

Based on the data presented in the table, the analysis of the learning design components shows scores ranging from 0.83 to 1.00, all categorized as very valid. The title, author, and reference indicators each achieved a score of 1.00, indicating that these elements are well-prepared and complete. The learning achievement indicator obtained a score of 0.94, reflecting alignment with the curriculum, while the learning objectives scored 0.83, suggesting that they are clear but still open to improvement. Both the material and exercise indicators received scores of 0.89, indicating that they are well-presented and effectively support the learning process. With an overall average score of 0.93, which falls into the very valid category, the learning design components in the PBL-based E-LKPD using Live Worksheets are deemed highly suitable for implementation.

The validation results for the fourth component are the utilization of supporting software in developing E-SWS. The software utilization component includes four indicators: 1) interactivity, 2) main software, 3) supporting software, and 4) originality. The analysis results for each indicator of the software utilization component are shown in Table 6.

Table 6. Results of the Software Utilization Component Analysis

Assessment Indicators	Average	Average
Interactivity	1	Very valid
Main Software	0,94	Very valid
Supporting Software	0,94	Very valid
Originality	1	Very valid
Overall Average	0,97	Very valid

Based on the data presented in the table, the analysis of the software utilization component shows scores ranging from 0.94 to 1.00, all of which fall within the very valid category. The interactivity and originality indicators each achieved a score of 1.00, indicating that the E-LKPD provides a high level of interaction and is developed with strong originality. Meanwhile, the main software and supporting software indicators each received a score of 0.94, suggesting that the use of Live Worksheets and additional supporting software is appropriate and effectively facilitates the learning process. Overall, the average score is 0.97, categorized as very valid, indicating that the software utilization component in the Problem-Based Learning-based E-LKPD using Live Worksheets is highly suitable for implementation in learning.

The validation results for the fifth component relate to the Problem-Based Learning model implemented in the student worksheet. This assessment includes five indicators: problem orientation, organizing learners, guiding investigations, developing and presenting results, and analyzing and evaluating. The analysis of each indicator within the PBL component is presented in Table 7.

Table 7. Results of the Analysis of Learning Model Components

Assessment Indicators	Average	Description
Problem Orientation	0,89	Very valid
Organizing	1	Very valid
Guiding Investigations	0,67	Valid
Developing and Presenting Results	0,89	Very valid
Analyzing and Evaluating	1	Very valid
Overall Average	0,89	Very valid

The analysis of the Problem-Based Learning implementation shows scores ranging from 0.67 to 1.00, categorized as valid to very valid. The organizing, analyzing, and evaluating indicators achieved the highest score (1.00), indicating well-structured and systematic stages, while problem orientation and developing and presenting results each scored 0.89, reflecting relevant problem context and adequate support for communicating findings. In contrast, the guiding investigations indicator obtained a lower score of 0.67 (valid), suggesting that this aspect still requires improvement, possibly due to limited scaffolding or less detailed guidance for students. Overall, the average score of 0.89 is classified as very valid, indicating that the PBL-based E-LKPD using Live Worksheets is generally appropriate for use in the learning process, with minor revisions needed in guiding investigations. The validation results for the sixth component addressed creative thinking skills, which consist of four indicators: fluency, flexibility, originality, and elaboration. The analysis of each of these indicators is presented in Table 8.

Table 8. Results of the Analysis of the Integration Components of Creative Thinking Ability

Assessment Indicators	Average	Description
Fluency	0,89	Very valid
Flexibility	0,83	Very valid
Originality	0,83	Very valid
Elaboration	1	Very valid
Overall Average	0,89	Very valid

Based on the data in the table, the analysis of creative thinking ability indicators ranges from 0.83 to 1.00, categorized as highly valid. The fluency indicator scored 0.89, indicating that the E-LKPD is capable of encouraging students to generate diverse ideas. The flexibility and originality indicators each scored 0.83, indicating that the E-SWS can help students find diverse solutions and generate diverse ideas. Meanwhile, the elaboration indicator scored 1.00, indicating that the E-SWS can facilitate students in developing ideas in greater detail. The overall average score was 0.89, categorized as highly valid, thus declaring the developed E-LKPD suitable for facilitating students' creative thinking skills.

The validity test results of the E-SWS developed through a Problem-Based Learning approach using Live Worksheets were obtained from evaluations by three expert lecturers in physics education. The assessment encompassed several components in the validation instrument, including Material Substance (SM), Visual Communication Display (VCD), Learning Design (LD), Software Utilization (SU), the Problem-Based Learning (PBL) model, and Creative Thinking Skills (CTS). Based on the scores for each indicator in the validation sheet, the average value for each component was determined. In this analysis, validation scores are displayed on the x-axis, while the assessment indicators are shown on the y-axis. The overall findings of the component validity analysis are presented in Fig 1.

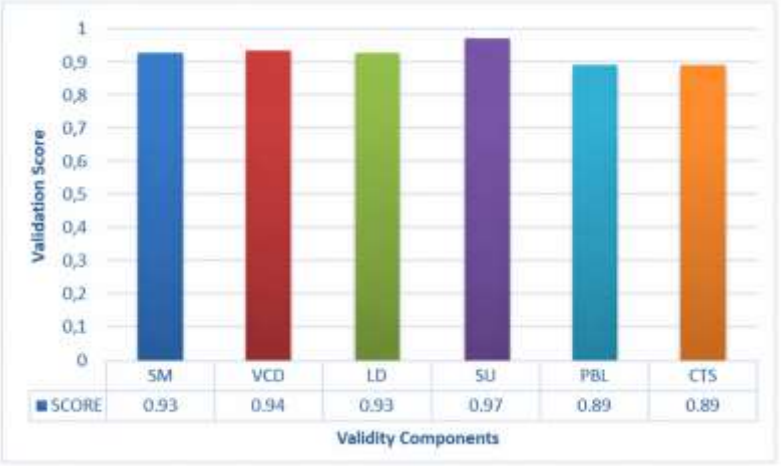

Fig 1. Average Validation Results for the Renewable Energy E-LKPD

The figure indicates that the validity scores for each component of the E-LKPD assessment fall within the range of 0.89 to 0.97, with an overall average of about 0.93. This result suggests that the PBL-based E-LKPD integrated with creative thinking skills is classified as highly valid. It implies that the developed product satisfies the feasibility criteria in terms of content, presentation, and design. In addition, the alignment between the material, the application of the learning model, and the enhancement of creative thinking skills is consistent with the learning objectives and students' needs, making it appropriate for use in the learning process.

Discussion

This study developed a Problem-Based Learning (PBL)-based E-LKPD integrated with creative thinking skills, which demonstrates a very high level of validity, as reflected by the average score of 0.93. This high validity can be attributed to several factors, including the strong alignment between the material and learning objectives, the systematic organization of PBL stages, and the clear, communicative presentation supported by interactive features in Live Worksheets. These elements ensure that the content is accurate, well-structured, and engaging, which are key criteria in developing effective ICT-based teaching materials[18]. The integration of multimedia features such as images, videos, and interactive exercises with automatic feedback further enhances student engagement and supports independent learning, in line with digital learning practices that facilitate communication and interaction between teachers and students[21] . Students are also accustomed to technological developments, particularly internet-based learning, which can increase their motivation to learn and engage with subject matter through advances in science and technology [22]

The application of the Problem-Based Learning model also contributes significantly to this high validity, as it emphasizes contextual problem-solving and actively involves students in the learning process. Through structured stages such as problem orientation, data collection, analysis, and presentation of results, students are encouraged to develop creative and higher-order thinking skills[19]. These findings are consistent with previous studies showing that Problem-Based Learning and the use of digital worksheets can improve students' engagement and creative thinking skills, particularly in physics learning contexts[23]

However, this study has several limitations. The developed E-LKPD is limited to a single topic, which restricts its generalizability to other physics materials. In addition, the study only focuses on validity testing and does not yet include practicality and effectiveness testing in real classroom settings. Therefore, further research is needed to implement the E-LKPD in broader learning contexts and to evaluate its impact on students' creative thinking skills more comprehensively.

IV. CONCLUSION

Based on the results of the validity data analysis, this study developed a Problem-Based Learning-based E-LKPD supported by Live Worksheets that is categorized as very valid. The evaluation covered six aspects: material content, visual display, learning design, software utilization, implementation of the Problem-Based Learning model, and creative thinking skills, with an overall average validity score of 0.93, indicating that the product meets the feasibility criteria for use in physics learning. The use of Live Worksheets also offers easy access and the potential to enhance student engagement. However, this study is limited to the validity stage and does not examine the effectiveness of the product in improving students' creative thinking skills. Therefore, this E-LKPD can be used as an alternative teaching material to support technology-integrated learning, while further research is recommended to test its practicality and effectiveness through direct classroom implementation.

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