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Development of Interactive E-LKPD Based on Socio Scientific Issues (SSI) on Renewable Energy Material to Facilitate Students' Critical Thinking

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Abstract: The lack of critical thinking skills among students is one of the causes of Indonesia's low science literacy score in PISA 2022. Socio Scientific Issues (SSI) learning can improve these skills by linking renewable energy material through real issues. With the SSI approach, this E-LKPD is expected to make physics learning more interesting and relevant through daily life, so that students can be more actively involved in the learning process and develop their critical thinking skills. This study aims to determine the results of material and media expert validation of E-LKPD and determine student readability of E-LKPD. The research method used is R&D (Research and Development) with the 4D research model, namely define, design, develop and disseminate. E-LKPD was developed in digital form through liveworksheet and validated by material experts, media experts, and tested for readability by students. The results of the material expert validation resulted in a percentage of 92.9%, which was categorized as very feasible; and the results of the media expert validation resulted in a percentage of 89.7%, which was also categorized as very feasible. The student readability test of the E-LKPD of 91.3% was classified as high.
***Keywords**: E-LKPD; Critical Thinking; Socio Scientific Issues (SSI); Renewable Energy*.

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Introduction

One of the most important things in education in the Unitary State of the Republic of Indonesia is science literacy. Based on the Organization for Cooperation and Development (OECD) through the Programme for International Student Assessment (PISA) in 2022 Indonesia showed a ranking of literacy learning outcomes up 5 to 6 positions compared to PISA 2018 (Kemendikbud RI, 2023). The results of the PISA 2022 study of Indonesia's science literacy score is 383 which is considered quite low located at 66 out of 81 countries. Science literacy skills in Indonesia are a matter of great concern, as evidenced by the low PISA results on the acquisition of science literacy. Low science literacy certainly has an impact on the quality of learning at school.

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This science literacy is closely related to students' critical thinking skills. This is because skill development requires a deep understanding of scientific concepts and processes, as well as the ability to interpret different information and make informed decisions (Azrai et al., 2020). The higher the literacy skills, the higher the level of critical thinking and vice versa. Efforts to improve critical thinking are to familiarize students with understanding science and its application in everyday life (Azrai et al., 2020).

The lack of direct involvement by students and the sole focus on the teacher causes students' critical thinking skills to be low and undeveloped (Effendi & Fauziah, 2022). This is because students have only been listening to the material taught by the teacher and have not actively participated in it, resulting in their critical thinking skills being weak and undeveloped (Agus, 2019). The need for critical thinking skills is very high and is considered important in problem-solving. Based on the facts, learning in schools does not involve students actively in problem-solving (Sahertian & Hidayati, 2022).

Students are the main object in the world of education which must play an active role in learning. Critical thinking skills are an essential ability in education, especially in science subjects such as physics (Amelia & Chusni, 2024). Critical thinking involves the ability to analyze, evaluate, and synthesize information, and make decisions based on evidence and logic (Saputra, 2021).

Improving critical thinking skills requires innovation and change in the learning process, including the use of learning media such as LKPD (Elfina & Sylvia, 2020). One of the media that can be used in learning is interactive media. Interactive media also plays an important role because it makes it easier for teachers to convey information to students and helps the learning process to be more active and fun. There is a need for interactive and innovative LKPD to increase students' critical thinking power, so it is made in electronic form called E-LKPD. Electronic Student Worksheets (E-LKPD) are learning tools that utilize the internet, arranged systematically for a particular unit of study, and presented in electronic format (Sianipar et al., 2023). E-LKPDs offer more varied content compared to printed student worksheets. In addition to narratives, images, and graphics, E-LKPDs are also equipped with various interactive features such as audio, music, animation, video, and direct clickable links (Sirmayeni, 2023).

Learning that is able to connect critical thinking skills with social life and science is socio scientific issues (SSI) learning. Socio scientific issues are representations of issues in society related to science in social aspects (Sirmayeni, 2023). SSI is very important to be applied in interactive learning between teachers and students. Linking physics material in everyday life is one way to change students' understanding by providing interesting issues and phenomena related to everyday physics. The application of SSI in physics learning can help students in associating physics learning with daily life phenomena (Febriani et al., 2023).

According to Apriliana Effendi et al. (2022) energy source material is material that cannot be separated from student life and is still a growing problem in society, so this material is suitable in the context of socio scientific issues (SSI) which makes students participate in solving a problem and improving students' critical thinking skills. Physics learning material in high school that has a connection with everyday life is renewable energy material. Renewable energy, which includes solar, wind, hydro, biomass, and geothermal energy, is a major focus amid increasing attention to environmental and sustainability issues (Tatsar et al., 2022). Renewable energy learning is not only about renewable energy technology and production but also emphasizes the importance of critical thinking in considering energy sources, their impact on the surrounding environment, and the possibility of application in various contexts. The analysis of critical thinking skills in physics learning on renewable energy material is important because it can help students not only understand basic concepts, but also develop the ability to evaluate information, identify problems, and find innovative solutions (Mahardika et al., 2023). This better prepares students to respond to global

challenges in energy and the environment (Amelia & Chusni, 2024). This research is similar to the research of Sianipar et al. (2023) but they focused on the general potential of E-LKPD to improve critical thinking skills in various contexts. In contrast, this study specifically examines the application of SSI-based E-LKPD in physics learning of renewable energy material.

A well-designed E-LKPD can encourage students to think critically about renewable energy issues. Through activities such as simulation, project design, and data analysis, students can develop problem-solving skills and the ability to make decisions that have a positive impact on the environment (Erianti et al., 2022).

The initial analysis at one of the SMANs in Tangerang Regency found that physics learning about renewable energy is less interactive and interesting and has not been applied E-LKPD based on socio scientific issues (SSI). Previous research by Apriliana Effendi et al. (2022) and Sahertian & Hidayati (2022) mentioned that students' active involvement in learning is essential to develop critical thinking skills. Lack of direct student involvement and a greater focus on the teacher's teaching methods lead to low students' critical thinking skills, which is consistent with the results of the initial analysis at SMAN Tangerang. According to Azrai et al. (2020) and Elfina & Sylvia (2020), the use of interactive learning media such as E-LKPD can improve student engagement and critical thinking skills. This is also consistent with the results of the initial analysis which shows the need for the development of SSI-based E-LKPD to make learning more interactive and support students' critical thinking skills on renewable energy material. Sianipar et al. (2023) and (Sirmayeni, 2023) emphasize that E-LKPDs that are well designed and contain diverse content can increase the attractiveness of learning and facilitate the development of students' critical thinking skills. This is in line with the results of the preliminary analysis which shows that physics learning at SMAN Tangerang needs to use SSI-based E-LKPD to make learning more interactive and interesting.

Overall, the results of the preliminary analysis are consistent with the findings from previous studies that emphasize the importance of interactive learning methods and active student involvement in developing science literacy and critical thinking skills. Previous research supports the need for innovations such as SSI-based E-LKPDs to facilitate more effective learning and improve students' critical thinking skills, hence the development of interactive E-LKPDs based on socio scientific issues (SSI) on renewable energy materials to facilitate students' critical thinking.

Method

This research is a type of Research and Development (RnD) research. Research and Development (RnD) is a method or step to create new products or develop and improve existing products and is used to test the effectiveness of these products (Okpatrioka, 2023). The purpose of the RnD approach is to create a product, which in this study is to make SSI-based interactive E-LKPD on renewable energy material that can facilitate students' critical thinking. This research uses a 4D research design consisting of define, design, develop, and disseminate.

The population in this study was the XI grade students of SMA Negeri 6 Tangerang Regency. The researcher took a sample of students in class XI Session 3 Physics at SMA Negeri 6 Tangerang Regency with a total of 1 class of 37 students. The sampling technique used was probability sampling (simple random sampling). Then this study requires validators to measure the feasibility of interactive E-LKPD that has been made, consisting of 4 material and media expert validators. Expert validation of E-LKPD in terms of material and media is an important step to ensure the quality and effectiveness of E-LKPD in learning.

This interactive E-LKPD development research procedure uses the 4D model. Some of the stages are:

Define

At this stage, identification of problems faced and needs analysis (problem analysis and CP) are carried out. The things that are done are through observations to schools by analyzing the situation and problems regarding physics learning at school. Conducting interviews with physics teachers.

Design

At this stage, designing the design and content of interactive E-LKPD content is carried out. Designing products that can provide solutions to the problems identified at the define stage. Then making interactive E-LKPD according to the SSI stages which are associated with indicators of critical thinking skills.

Develop

At this stage, validation by a team of experts and a student readability test are carried out. If there is an error or it is not feasible, there must be a revision first until it is said that the product is feasible for distribution. The validation results determine the level of feasibility of a product produced. Conducting a limited trial of students and later students will give feedback on the use of the interactive E-LKPD.

Disseminate

After going through the define, design, and develop stages, the next step is to disseminate by disseminating the interactive E-LKPD that has been made. However, product dissemination was not carried out because the aim of the research was to produce interactive E-LKPD based on Socio Scientific Issues (SSI) on renewable energy material to facilitate students' critical thinking and determine the feasibility and readability test of the E-LKPD so that the research was sufficiently carried out at the development stage or limited testing to determine students' reactions to the readability of E-LKPD.

The instruments used in this study consisted of expert validation sheets (material and media) assessed by experts and student readability test questionnaires on E-LKPD. The material expert validation instrument is based on references from BSNP consisting of content, presentation and contextual feasibility. The media expert validation instrument refers to BSNP standards consisting of the size of interactive E-LKPD, interactive E-LKPD cover, interactive E-LKPD content design, straightforward, communicative, dialogical and interactive, suitability for learner development, and suitability for language rules. Students are given a readability test questionnaire on interactive E-LKPDs that have been used according to their aspects consisting of the appearance and readability of E-LKPDs, material content and relevance to renewable energy, socio scientific issues (SSI) approach, involvement and motivation to learn, and satisfaction and recommendations. Data collection techniques used expert validation questionnaires (material and media), and student readability test questionnaires on E-LKPD. Material and media experts amounted to 4 people, namely 2 lecturers and 2 physics teachers, while respondents amounted to 37 students to determine the readability of E-LKPD.

Data obtained from research results such as expert validation results and student readability tests will be followed up to determine the feasibility and readability of the E-LKPD made for analysis and improvement of researchers. There are two types of data, namely qualitative and quantitative data. Qualitative data analysis is data analysis used to analyze data collected from questionnaires. Qualitative data includes student responses as well as comments from material and media experts. While quantitative data is obtained from evaluating the quality of materials and media. Quantitative data analysis with descriptive statistics to determine the feasibility and readability of E-LKPD. The data obtained from the validation results of the expert team were analyzed using a Likert scale, while the data obtained from the results of the student readability test were analyzed using a guttman scale. Test scores using a Likert scale can be seen in Table 1 and test scores using a guttman scale can be seen in Table 2.

Table 1. Likert Scale

Criteria	Score
Very Unfeasible	1
Not Feasible	2
Less Feasible	3
Feasible	4
Very Feasible	5

Table 2. Guttman Scale

Criteria	Score
Yes	1
No	0

The rating scale obtained is then processed into a percentage using the following equation:

$$Percentage\ Score = \frac{Total\ number\ of\ scores\ (x)}{Maximum\ number\ of\ scores\ (x_i)} \times 100\% \quad (1)$$

Then the next activity is to interpret the percentage results by grouping the percentage results of expert validation into the assessment interpretation criteria based on the Likert scale, according to Table 3, while for the results of the student readability test questionnaire are grouped based on the guttman scale assessment interpretation criteria according to Table 4:

Table 3. Interpretation Criteria for Feasibility Assessment

Percentage Range (%)	Criteria
80% < x ≤ 100%	Very Feasible
60% < x ≤ 80%	Feasible
40% < x ≤ 60%	Less Feasible
20% < x ≤ 40%	Not Feasible
0% < x ≤ 20%	Very unfeasible

Table 4. Interpretation Criteria for Readability Test Assessment

Percentage Range (%)	Criteria
≥67,71%	High
34,36-66,71%	Medium
≤33,36%	Low

Results and Discussion

Define

Critical thinking skills are needed and considered important in problem solving. School activities are planned in such a way that students actively participate to achieve learning objectives. One of the media that can be used in learning is interactive media. There is a need for interactive and innovative LKPD to facilitate students' critical thinking. So it is made in electronic form called E-LKPD. Electronic Student Worksheets (E-LKPD) are learning tools that utilize the internet, arranged systematically for a particular unit of study, and presented in electronic format. Learning that is able to connect critical thinking skills with social life and science is socio scientific issues (SSI) learning. Socio scientific issues are representations of issues in society that relate to science in social aspects. The application of SSI in physics learning can help students in associating physics learning with daily life phenomena. According to Apriliana Effendi et al (2022) energy source material is material that cannot be separated from student life and is still a growing problem in society, so this material is suitable in the context of socio scientific issues (SSI) which makes students participate in solving a problem and improving students' critical thinking skills. Physics learning material in high school that has a connection with everyday life is renewable energy material. Analysis

of critical thinking skills in physics learning on renewable energy material is important because it can help students not only understand basic concepts, but also develop the ability to evaluate information, identify problems, and find innovative solutions.

Design

This E-LKPD consists of 2 E-LKPDs, namely E-LKPD of renewable energy and non-renewable energy material, and the second is E-LKPD of non-renewable energy mitigation material and PLTS. The display is designed as a digital or electronic LKPD that is connected to the internet and other sources using a liveworksheet website in contrast to previous studies such as (Elfina & Sylvia, 2020), which focus more on developing print-based or PDF LKPD without interactive elements.

Figure 1. Display of E-LKPD 1 Renewable Energy and Non-Renewable Energy Material on the Liveworksheet Website

In E-LKPD renewable energy material contains objectives and work instructions; apperception regarding the origin of electrical energy used daily apparently comes from fossil energy; motivation contains questions about dependence on fossil energy; the content consists of the stages of SSI, namely the approach and analysis of the problem in the form of issues related to air pollution caused by PLTU, clarifying the problem by making observations, continuing the issue of social problems by answering questions as a stimulus to reveal the problem, discussion and evaluation contains questions to reveal alternative problem solving from the social issues given and is also filled with classifying energy sources that include renewable energy and non-renewable energy, and conclusions that contain metareflection.

Figure 2. Display of E-LKPD 2 Material Mitigation of Nonrenewable Energy and Solar Power Plant on the Liveworksheet Website

The E-LKPD on non-renewable energy mitigation material and PLTS contains objectives and work instructions; apperception regarding the application of PLTS on the roof of the house; motivation contains questions about the transition to renewable energy and public awareness of the importance of transition to renewable energy; the content consists of the stages of SSI, namely the approach and analysis of the problem in the form of issues related to the uneven energy mix, clarification of the problem by making observations, continuing the issue of social problems by answering questions as a stimulus to reveal the problem, discussion and evaluation containing questions to reveal alternative problem solving from the social issues given, and conclusions containing metareflection.

Develop

The activity is filled with making interactive E-LKPD according to the SSI stage which is associated with indicators of critical thinking skills, then after that validation by a team of experts and student responses. Based on the validation of the four validators, the results of the material expert validation can be seen in Figure 3, and the results of the media expert validation can be seen in Figure 4.

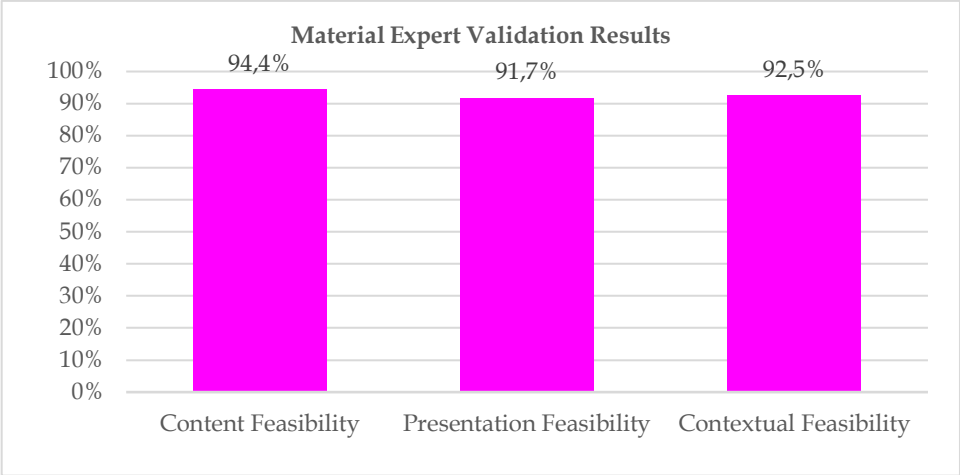

Figure 3. Diagram of Material Validation Results

From the four validators, the content feasibility aspect scored 94.4%, categorized as very feasible; presentation feasibility scored 91.7%, categorized as very feasible; and contextual feasibility scored 92.5%, categorized as very feasible. It can be seen from these three aspects that the presentation feasibility aspect has the lowest score while the highest score is achieved by the content feasibility aspect. When viewed from the material validation questionnaire by experts, this could be due to the presentation of example questions that are less able to increase students' understanding.

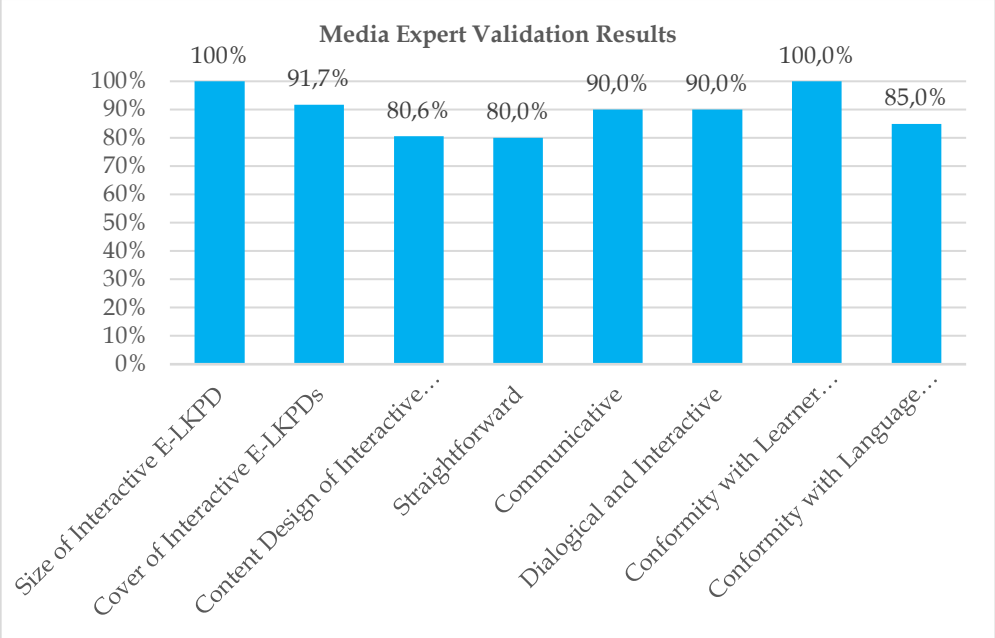

Figure 4. Diagram of Media Validation Results

From the four validators, the validation results for media aspects are as follows: Interactive E-LKPD size 100%, categorized as very feasible; interactive E-LKPD cover 91.7%, categorized as very feasible; interactive E-LKPD content design 80.6%, categorized as very feasible; straightforward 80%, categorized as feasible; communicative 90%, categorized as very feasible; dialogical and interactive 90%, categorized as very feasible; conformity with learner development 100%, categorized as very feasible; and the last is conformity with language rules 85%, categorized as very feasible. It can be seen from these eight aspects that the straightforward aspect has the lowest score while the highest score is achieved by the

interactive E-LKPD size aspect and conformity with learner development. When viewed from the media validation questionnaire by experts, this could be caused by the lack of effectiveness of the sentences used in the E-LKPD.

Furthermore, the product was revised based on the suggestions and input from the validators. The product was tested on students, and afterwards students were encouraged to fill in the questionnaire provided to assess their readability.

This limited trial was conducted on 37 students of class XI SMA Negeri 6 Tangerang Regency. There are 5 aspects assessed, namely aspects of the appearance and readability of E-LKPD to assess the type of font, image, color, use of language that is easy to understand, and graphic layout; aspects of material content and relevance to renewable energy to assess the ease of understanding the material and its relevance to renewable energy; aspects of the socio scientific issues (SSI) approach to assess students' critical thinking so that their minds are open to social environmental problems that have to do with science; aspects of learning engagement and motivation to assess student interest in E-LKPD; and the last is the aspect of satisfaction and recommendations to find out whether students are satisfied with this E-LKPD and whether it is worth recommending in learning or not. The results of the limited trial to students regarding the acceptance of E-LKPD can be seen in Figure 5.

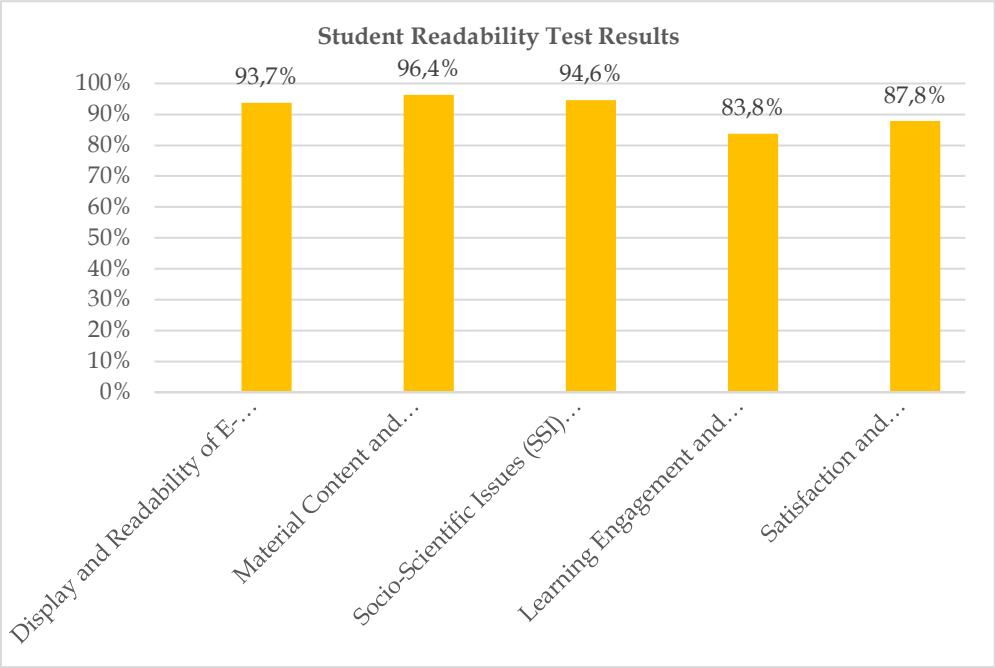

Figure 5. Diagram of Student Readability Test Results

In terms of the appearance and readability aspects of E-LKPD, the result was 93.7% with a high category; the aspect of material content and relevance to renewable energy obtained a result of 96.4% with a high category; the aspect of socio scientific issues (SSI) approach obtained a result of 94.6% with a high category; the aspect of involvement and motivation to learn obtained a result of 83.8% with a high category; and the aspect of satisfaction and recommendations obtained a result of 87.8% with a high category. It can be seen from these five aspects that the aspect of learning involvement and motivation has the lowest score while the highest score is achieved by the aspect of material content and relevance to renewable energy. When viewed from the student readability test questionnaire, this could be due to the lack of motivation of students to learn renewable energy independently. These results are similar to research by (Tatsar et al., 2022), which shows that student interest in renewable energy learning often requires additional stimulation, such as creativity-based projects.

The feasibility of this SSI-based E-LKPD is based on the results of material and media expert validation, as well as student responses to the readability of E-LKPD for students in learning. At the validation stage, suggestions for improvement were given related to improving sentence structure, and completeness of references to news, images, or videos. The results of the E-LKPD assessment can be seen in Table 5 for material validation and Table 6 for media validation.

Table 5. Average Material Expert Validation Results

Validator Name / Aspect	Validator 1	Validator 2	Validator 3	Validator 4	Total Average
Content Feasibility	88,9%	91,1%	100%	97,8%	94,4%
Presentation Feasibility	93,3%	96,7%	90%	86,7%	91,7%
Contextual Feasibility	90%	95%	90%	95%	92,5%
Validator Average	90,7%	94,3%	93,3%	93,1%	**92,9%**

Table 6. Average Media Expert Validation Results

Validator Name / Aspect	Validator 1	Validator 2	Validator 3	Validator 4	Total Average
Size of Interactive E-LKPD	100%	100%	100%	100%	100%
Interactive E-LKPD cover	90%	93,3%	93,3%	90%	91,7%
Content Design of Interactive E-LKPD	92,5%	97,5%	65%	67,5%	80,6%
Straightforward	80%	80%	60%	100%	80%
Communicative	80%	80%	100%	100%	90%
Dialogical and interactive	80%	80%	100%	100%	90%
Conformity to Learner Development	100%	100%	100%	100%	100%
Conformity with Language Rules	80%	80%	80%	100%	85%
Validator Average	87,8%	88,9%	87,3%	94,7%	**89,7%**

Based on the assessment of the material expert validator, an average score of 92.9% was obtained, which was categorized as very feasible, then the results of the media expert validation obtained an average score of 89.7%, also categorized as very feasible. After validating the material and media experts, the next stage is a limited trial to 37 students to determine the students' readability response to E-LKPD. The average score obtained was 91.3%, categorized as high, as shown in Table 7.

Table 7. Average Student Readability Test Results

Aspect	Percentage
Display and Readability of E-LKPD	93,7%
Material Content and Relevance to Renewable Energy	96,4%
Socio-Scientific Issues (SSI) Approach	94,6%
Learning Engagement and Motivation	83,8%

Satisfaction and Recommendation	87,8%
Average	**91,3%**

The overall assessment of the E-LKPD is summarized in Table 8.

Table 8. Overall Assessment of E-LKPD

Assessment	Score (%)	Description
Material Validation	92,9%	Very feasible
Media Validation	89,7%	Very feasible
Student Readability Test	91,3%	Very feasible
Average	91,3%	Very feasible

Based on the results of the overall assessment of E-LKPD, the average percentage of suitability was 91.3%, with a very feasible category. In this study, the validation of material experts, media, and student readability tests showed a very feasible category with an average score of 92.9% and 89.7%, and 91.3%. These results are in line with a study by (Sianipar et al., 2023), which also showed the effectiveness of SSI-based E-LKPDs in improving students' understanding of science materials, although their focus was more on chemistry than physics. Thus, the SSI-based interactive E-LKPD on renewable energy material to facilitate students' critical thinking can be utilized and used in learning physics class X high school curriculum.

Conclusion

The development of interactive E-LKPD based on socio scientific issues (SSI) on renewable energy material to facilitate students' critical thinking was carried out through modified 4D stages, namely define, design, and develop. The results of validation by material and media experts showed an average score of 92.9% and 89.7%, indicating that this E-LKPD is very feasible to use. In addition, the results of the readability test by students who reached a score of 91.3% also strengthened the feasibility of this product as an effective interactive learning tool in high school physics subjects. So that the overall average percentage is 91.3% which is categorized as very feasible. Thus, the SSI-based interactive E-LKPD on renewable energy material to facilitate students' critical thinking can be utilized and used in learning physics class X independent high school curriculum. It is recommended to conduct further research to determine the effectiveness and impact of this interactive E-LKPD on students' critical thinking skills on the topic of renewable energy. In addition, this SSI-integrated interactive E-LKPD is expected to be more useful if it is developed for other physics topics as needed.

It is recommended to conduct further research to determine the effectiveness and impact of this interactive E-LKPD on students' critical thinking skills on the topic of renewable energy. In addition, this SSI-integrated interactive E-LKPD is expected to be more useful if it is developed for other physics topics as needed.

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