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Green Learning Revolution: Needs Analysis of Engineering Design Process-Based E-LKPD for Pineapple Waste Biogas in Senior High School

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Abstract

This study aims to analyze the need for developing Physics E-LKPD (e-student worksheet) based on the Engineering Design Process (EDP) within the context of utilizing pineapple waste as biogas as an alternative renewable energy. The background of this study is based on physics learning that lacks context and low student learning independence. This study uses a quantitative descriptive approach involving 63 students from grades X and XI at State Senior High School 6 Prabumulih. Data was collected to identify the learning conditions and needs of students in physics education. The findings show that most students have access to digital devices and internet connectivity; however, physics learning resources are still dominated by conventional printed teaching materials, and the implementation of E-LKPD is not yet optimal. Nevertheless, students showed a high level of interest in the topic of renewable energy and responded positively to project-based learning contexts. These findings reveal a gap between students' digital readiness and the availability of interactive and innovation-oriented teaching materials. Therefore, this study aims to develop E-LKPD based on the Engineering Design Process (EDP) in the context of biogas from pineapple waste to support independent learning, improve critical thinking skills, and foster awareness of renewable energy innovation. The implications of this study indicate that the integration of EDP-based E-LKPD Physics and local wisdom, such as the use of pineapple waste to produce biogas, can increase students' independence in learning, critical thinking, and environmental awareness, as well as support curriculum development, learning practices, and real-world problem solving that are relevant to the potential of the region.

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INTRODUCTION

Learning in the 21st century is aimed at preparing the current generation to face various challenges and demands at the global level. In an ever-evolving digital age, technology has become an important component in almost every sector, including education (Herawati et al., 2024; Rabani et al., 2023). Physics learning is often considered a difficult, boring, uninteresting, and sometimes frightening subject by students (Amalissholeha et al., 2023; Mahmudah et al., 2022; Sulastri et al., 2024). This is due to the presentation of material that tends to be abstract, lacking in context, and has little relevance to its application in everyday life (Daun & Haris, 2020; Patandean et al., 2023). In fact, physics education has

great potential to develop higher-order thinking skills that are essential in the 21st century, such as critical, systematic, and creative thinking skills. One important skill that needs to be improved is engineering thinking, which is the ability to think systematically in solving real-world problems (Lin et al., 2021). This skill is very important in addressing global strategic issues, including the energy crisis and environmental sustainability.

One important issue currently being faced is the increasing demand for renewable energy and the issue of organic waste management (Zimoglyad et al., 2021). Dependence on fossil fuels has a serious impact on the environment (Aprianto et al., 2024), while untreated organic waste has the potential to cause soil and water pollution (Tariq & Mushtaq, 2023). Conversely, organic waste such as pineapple waste has high potential as a source of biomass energy (Aili et al., 2021). The city of Prabumulih in South Sumatra Province is one of the regions with abundant pineapple production. So far, pineapple waste, which consists of peel, stalks, and processing residues, has not been fully utilized despite its organic content having great potential as a raw material for biogas through anaerobic fermentation. Therefore, the utilization of pineapple waste not only reduces pollution but also becomes a source of renewable energy that supports sustainable development.

Biogas produced from pineapple waste has great potential to be integrated into physics education to make it more relevant and practical. However, in practice, physics education in schools is generally theoretical without direct experience (Wati et al., 2024). It also rarely connects with local wisdom. By connecting scientific concepts with cultural contexts and local wisdom, students can understand and apply this knowledge in their daily lives (Rahman et al., 2025). This approach not only makes the material more relevant, but also increases students' interest and enthusiasm for learning (Verawati & Wahyudi, 2024).

To address these challenges, one teaching material that can be developed is E-LKPD. Through E-LKPD, students not only obtain information but are also challenged to explore, analyze, and solve problems collaboratively. LKPD usually contains various activities, assignments, and questions that encourage students to think critically, interact with the material, and relate the concepts learned to real-life (Mailani et al., 2024). To be more effective, E-LKPD can be developed using the Engineering Design Process (EDP) approach, which includes several stages, namely define, learn, plan, try, test, and decide (Crawford et al., 2017). This approach provides a project-focused learning experience, training students to think logically, creatively, and systematically when faced with real-world problems (Rehman et al., 2024).

A needs analysis is essential to ensure that teaching materials are appropriate for the characteristics and technological readiness of students (Afrianis & Ningsih, 2022; Dewi, 2022). Although E-LKPD, based on the Engineering Design Process (EDP), has been developed on various renewable energy topics, the integration of the biogas context from pineapple waste in physics learning has not been widely studied. This gap forms the basis for the novelty of this study, which focuses on analyzing the needs for developing E-LKPD Physics based on EDP within the context of utilizing pineapple waste as biogas as an alternative renewable energy source.

Based on the above description, this study focuses on analyzing the needs for developing E-LKPD Physics based on EDP in the context of utilizing pineapple waste to produce biogas. This innovation is expected to provide physics learning that is more contextual, applicable, and relevant to the daily lives of students at State Senior High School 6 Prabumulih. In addition to improving understanding of renewable energy concepts, this study also aims to foster students' awareness of the importance of environmentally friendly innovations in facing future global energy challenges.

METHODS

This study is a quantitative descriptive study with supporting qualitative data, which aims to describe or present phenomena that occur in a real, actual, realistic, systematic, factual manner, with accurate facts and characteristics related to the phenomena being studied (Sugiyono, 2017). The data obtained are qualitative and quantitative data. Qualitative data were obtained from interviews with physics teachers, which aimed to explore the physics learning process that had been implemented, the teaching materials used, and the challenges faced by teachers in teaching physics at the school. Furthermore, quantitative data was obtained from the results of a questionnaire analyzing the needs of students that had been distributed. The research subjects consisted of 63 people, who were a combination of 10th and 11th grade students at State Senior High School 6 Prabumulih.

A needs analysis was conducted to identify the needs in physics learning at State Senior A needs analysis was conducted to identify the needs in physics learning at State Senior High School 6 Prabumulih. This study focused on the characteristics of students and their interest in electronic teaching materials. A questionnaire was systematically developed based on indicators relevant to the research objectives and supported by teacher interviews to obtain qualitative data. The integration of quantitative questionnaire data and qualitative interviews allows for a more comprehensive understanding of students' needs and expectations. With this approach, the study is expected to provide appropriate guidance in the development of physics learning, particularly in supporting students to develop critical thinking skills more effectively.

This study analyzes data using descriptive statistical techniques, which aim to process, summarize, and present data in a structured manner so that it is easier to understand. The results of the needs analysis are analyzed using a formula whereby the total score obtained is divided by the maximum score and then multiplied by 100.

The criteria for determining needs analysis can be seen in Table 1.

Table 1 Questionnaire data analysis

Answer Categories	Score
Strongly agree	5
Agree	4
Neutral	3
Disagree	2
Strongly Disagree	1

Sugiyono in Sulastry (2021)

RESULTS AND DISCUSSION

This research was conducted at State Senior High School 6 Prabumulih. Data was obtained through interviews with one of the physics teachers and by distributing student needs analysis questionnaires designed in the form of a Likert scale. The collected data was then analyzed quantitatively to determine students' perceptions and needs regarding the use of E-LKPD based on the Engineering Design Process, utilizing pineapple waste to produce biogas as an alternative renewable energy source in physics learning. The results of the interviews are presented in Table 2, which describes the various challenges faced in physics learning.

Table 2 Interview with teachers at State Senior High School 6 Prabumulih

No	Interview Questions	Teacher's Answer
1	What challenges do mothers often face in teaching physics?	The challenge lies with the students, most of whom are not yet independent learners, so teachers must play a greater role in the learning process.
2	What causes students to lack independence in learning?	The cause is a lack of learning experience. At previous levels, students have not had varied learning experiences; their learning tendencies are more often listening to

No	Interview Questions	Teacher's Answer
		teachers' explanations, taking notes, and doing exercises. They are still not well-trained in critical thinking.
3	Are there other reasons why students tend to be passive?	Some students come to school without having prepared their lessons at home. So when they receive the material, they really have no knowledge whatsoever. When asked basic questions about material they should have studied, they tend to remain silent because they don't know or have forgotten the material.
4	For the physics lab, what kind of experiments have you done?	Using virtual laboratories such as PhET Simulation and Lab Maya for some abstract materials. For practical work that can be done directly, the tools can be brought from home or directly from the laboratory. However, more often than not, simple tools are made to apply physics concepts
5	What teaching methods/models do you often use when teaching physics at school?	The learning model is more of an active learning model, such as cooperative learning, PBL, PjBL, discovery, and inquiry. The learning methods usually combine several methods in learning, such as lectures, discussions, and presentations. There are also practicals or demonstrations, discussions, and presentations.

Based on interviews with physics teachers, several challenges were identified that formed the basis for developing EDP-based E-LKPD. The main challenge in learning is that most students are not yet independent in their learning, so teachers must take a more dominant role in the classroom. This lack of independence is due to limited previous learning experiences, where students more often listen to the teacher's explanations, take notes, and do exercises without being given experiences that train critical thinking skills. Independent learning is an activity carried out consciously in the learning process, based on the motivation to master knowledge so that it can be used to solve problems encountered (Ramadani et al., 2023). Independent learning is also defined as a state of learning that does not depend on others, involving desire, initiative, and responsibility in completing learning challenges. Independent learning can be observed from various aspects, such as curiosity, interaction with learning resources, and the ability to learn independently without relying on others (Syahiddah et al., 2021). In addition, there are still many students who come to school without preparing their lessons at home, so they tend to be passive during learning and have difficulty answering basic questions that they should have mastered.

In physics teaching practice, teachers have used virtual laboratories such as PhET Simulation and Lab Maya for abstract material, as well as simple equipment for hands-on practice. However, interviews show that the active learning models applied, although varied (cooperative learning, PBL, PjBL, discovery learning, and inquiry learning), have not fully encouraged student independence in learning and critical thinking skills. This condition emphasizes the need for E-LKPD based on the Engineering Design Process (EDP) that not only presents concepts theoretically but also actively involves students in finding solutions. By raising the context of utilizing pineapple waste as biogas as renewable energy, this E-LKPD becomes contextually relevant and supports the development of 21st-century skills, including problem-solving, collaboration, and critical thinking. The results of the student needs analysis obtained through the distribution of questionnaires can be seen in Table 3.

Table 3 Results of the student needs analysis questionnaire

No	Statement	Frequency		Percentage	
		Yes	No	Yes	No
1	Do you have a digital device (e.g., cell phone/laptop)?	63	0	100%	0%
2	Do you often use digital devices to access learning materials?	61	2	96.8%	3.2%
3	Is the internet connection in your area adequate?	56	7	88.9%	11.1%
4	Do you feel you have sufficient resources, such as textbooks, online materials, or teacher assistance, to help you understand renewable energy?	48	15	76.2%	22.22%
5	Are there any agricultural activities around your residence that utilize or process pineapple waste?	42	21	66.7%	33%

Based on the results of a questionnaire analyzing student needs, data shows that all students (100%) already have digital devices, either in the form of mobile phones or laptops. The rapid development of digital technology in the 21st century has encouraged students to learn and innovate. Effective use of digital technology accelerates the process of searching for information and improves life skills that are important for the world of work (Dewi, 2024). Most students (96.8%) are accustomed to using these digital devices to access learning materials, while only 3.2% rarely use them. This habit reflects students' readiness to adapt to interactive and flexible digital learning. When technology began to be applied in learning, students' learning patterns changed from being passive and teacher-centered to being more active, independent, reflective, and collaborative (Rukli & Arfiani, 2025).

In terms of internet network availability, 88.9% of students stated that internet access in their neighborhood was adequate, although 11.1% still experienced difficulties. The availability of a stable and affordable internet network is an important factor in facilitating internet access (Fathimatuzzahra & Dompak, 2024). Regarding knowledge about the utilization of pineapple waste, 66.7% of students stated that there are agricultural activities around their neighborhoods that utilize or process pineapple waste, while 33% have not yet utilized or processed pineapple. In pineapple processing, this waste is often disposed of carelessly, which can cause environmental problems and reduce the effectiveness of resource use. However, pineapple waste has economic potential that can be utilized, for example, as raw material for biogas or organic fertilizer (Sembiring et al., 2025).

Furthermore, 76.2% of students felt that they had sufficient resources, both in the form of textbooks, online materials, and support from teachers, to understand renewable energy materials. This shows that most students have adequate digital facilities, good internet access, and an environment that supports learning about renewable energy, especially the use of pineapple waste to produce biogas. However, 22.22% of students still feel that there are limitations in this regard. Digital technology, including computers, the internet, and educational applications, has created new opportunities to improve the quality of education (Parveen & Ramzan, 2022). The learning process will become more interesting and provide broader access for students to obtain diverse learning resources. The integration of technology in the education sector creates a more collaborative, interactive, and adaptable way of learning for students (Wahyudi & Jatun, 2024). The details of the student needs survey results that support this analysis are shown in Table 4.

Table 4 Analysis of student needs questionnaire

No	Statement
1	92.1% of students have studied renewable energy
2	42.9% of students feel that renewable energy material is difficult to understand.
3	57.1% of students find it difficult to understand mathematical or physical concepts related to renewable energy.
4	60.3% of the students have implemented the Engineering Design Process (EDP)-based learning
5	25.4% were very interested, and 60.3% were interested in the use of E-LKPD based on the Engineering Design Process (EDP) in physics learning.
6	8.6% are very willing, and 58.7% are willing to try E-LKPD, which discusses the use of pineapple waste to produce biogas using the Engineering Design Process (EDP) approach.
7	38.1% of respondents were unaware of the uses of pineapple waste. However, 34.9% who were aware mentioned that pineapple waste is usually used as fertilizer or compost, while 25.4% said it is used as animal feed. Its use as biogas also emerged, although the percentage was lower at 14.3%. Meanwhile, 12.7% of respondents stated that pineapple waste is simply discarded (12.7%).
8	77.8% of students use printed books as teaching materials, and 17.5% of students use LKPD/E-LKPD.
9	30.2% of students stated that they sometimes use E-LKPD, 23.8% rarely use it, and 19% never use it. Meanwhile, only 15.9% often use E-LKPD, and 11.1% always use it. This shows that the use of E-LKPD in learning is still relatively low and inconsistent.
10	57.1% of students feel it is important to learn about renewable energy.
11	55.5% of students showed a high interest in learning more about renewable energy.
12	66.6% of students feel that the renewable energy assignments or projects given in class are helpful.

Based on the results of the student needs analysis questionnaire, it was found that 92.1% of students had studied renewable energy materials. However, 42.9% of them felt that the material was difficult to understand, and 57.1% stated that they had difficulty understanding the mathematical and physical concepts related to renewable energy. To overcome these limitations, a contextual approach provides a suitable solution. By linking learning materials to real-world situations, this approach provides students with meaningful learning experiences (Suhermi et al., 2025). A total of 60.3% of students admitted to having applied EDP-based learning. The level of student interest in the development of EDP-based E-LKPD is also quite high, with 25.4% stating that they are very interested and 60.3% interested. A total of 8.6% of students stated that they are very willing, and 58.7% are willing to try E-LKPD, which discusses the use of pineapple waste into biogas with an EDP approach. This fact shows a high level of interest in the integration of project-based learning and real environmental issues. Learning that focuses on the local context can encourage students to get directly involved in issues around them, thereby deepening their understanding of the relationship between learning and everyday life (Annisha, 2024). This is especially true in the context of using agricultural waste as an alternative renewable energy source. A total of 38.1% of students stated that they did not know anything about the use of pineapples, while 34.9% were aware that pineapple waste is usually used as fertilizer or compost. In addition, 25.4% stated that waste is used as animal feed, 14.3% as biogas, and 12.7% stated that pineapple waste is simply discarded without being utilized.

In terms of teaching materials, most students (77.8%) still use printed books, while only 17.5% use LKPD/E-LKPD. The use of E-LKPD is not yet optimal, with 30.2% of students only using it occasionally, 23.8% rarely, 19% never, 15.9% often, and 11.1% always using it in learning (Tafonao et al., 2019). LKPD generally only contains summaries of material and individual questions, so teaching materials that are integrated with technology, interesting, and innovative are needed (Gusyanti & Sujarwo, 2021). Furthermore, 57.1%

of students consider renewable energy learning important, 55.5% show a high interest in learning more about it, and 66.6% feel more helped when accompanied by assignments or projects in class. This trend indicates a real need for the development of E-LKPD based on EDP with the context of utilizing pineapple waste into biogas, which can increase student active engagement, critical thinking, and contextual learning.

It can be concluded that the development of E-LKPD based on the Engineering Design Process with the theme of utilizing pineapple waste into biogas is highly relevant, as it meets the needs of students while also improving their understanding, critical thinking skills, and interest in renewable energy.

CONCLUSION

The results of the study indicate that the development of E-LKPD Physics based on the Engineering Design Process (EDP) with the context of biogas from pineapple waste is relevant to the needs of students at SMA Negeri 6 Prabumulih, especially to improve their understanding of concepts, critical and creative thinking skills, and awareness of renewable energy innovation. The main obstacles found were that physics learning was still theoretical and lacked context, and that students had low learning independence. Based on these findings, EDP-based E-LKPD can be used as a basis for developing more effective and innovative teaching materials. The limitations of this study include the limited scope of participants and the fact that the needs analysis was only conducted in one school, so the results may not necessarily represent the conditions in other schools. The implications of this study include opportunities for broader development of E-LKPD to support the mastery of 21st-century skills and contribute to the achievement of the Sustainable Development Goals (SDGs) in the field of clean and environmentally friendly energy. However, this study has limitations because the needs analysis was only conducted in one school, so the findings cannot represent various educational contexts. Nevertheless, the implications show that EDP-based E-LKPD can increase students' independence and analytical skills through activities that involve experiments and real-world problem solving.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, RA and S; methodology, RA and S; conducting the experiments and data analysis, RA; writing—original draft, RA; reviewing and editing, S.

AI DISCLOSURE STATEMENT

The author used ChatGPT in a limited capacity during the preparation of this work for conceptual exploration and preliminary structuring of ideas. The main concepts, analysis, and final content were developed independently. After using the tool, the author thoroughly reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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