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Teachers' Perception toward e-LKPD STEM-EDP to Improve System Thinking Skills and Creative Problem Solving Skills

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Abstract: This study investigates the needs of teachers and students in physics education, focusing on renewable energy. It aims to describe a valid e-LKPD (electronic student worksheet) for Alternative Energy Learning based on the STEM Engineering Design Process (EDP) to enhance students' System Thinking Skills and Creative Problem Solving Skills through qualitative and quantitative methods. A survey of 20 high school physics teachers in Lampung Province revealed that 77.8% use the STEM model for teaching, but only 72.2% of students engage in setting goals and defining problems. These findings indicate that current e-LKPDs are inadequate, lacking activities to develop the necessary skills. Thus, there is a clear need for more effective e-LKPDs to provide a more engaging and comprehensive learning experience.

Keywords: EDP; Problem solving; Renewable energy; STEM-EDP; System thinking skills

Introduction

Merdeka Curriculum is a new curriculum concept in Indonesia introduced by the Ministry of Education and Culture in 2021 (Arrohman et al., 2023). The aim of this curriculum is to provide greater freedom to schools in developing a curriculum that suits the local context and the needs of students (Manalu et al., 2022). In the 21st century, education is required to prepare students to practice and develop a range of abilities and skills, particularly high-level system thinking skills and creative problem solving (Waluyo, 2023). Education is required to be able to create competent students who are able to compete globally in adapting to developments in the 21st century. Efforts that can be made to have 21st century skills are to improve the quality of 21st century learning. In the 21st century, students are required to have 4C skills consisting of critical thinking skills (Critical Thinking), communication (Communication), creative thinking (Creative Thinking) and collaboration (Collaboration) (Maya et al., 2015).

These skills will increase tolerance for diversity, improve critical thinking skills, creativity in solving problems and be able to relate them between theory and real life (Almarzooq et al., 2020). System thinking skills are one of the skills in the 21st century. System thinking skills are needed by the next generation for the very complex challenges of the future.

According to Meilinda et al. (2018) system thinking skills are the ability of students to think about the system character of a phenomenon. Complex problem solving abilities can be identified and stimulated through the instillation of system thinking skills. System thinking skills have a close relationship with creative thinking skills, where creative thinking skills are one of the skills in the 21st Century.

According to Abdurrahman (2019) System thinking skills refer to students' ability to think about the systemic characteristics of a phenomenon. One of the integrated STEM-Engineering Design Process (EDP) approaches to teaching Alternative Energy (renewable) involves providing a creative and innovative space (maker space). Satriawan et al. (2021) for physics teachers in developing system thinking skills and students'

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awareness of the future world in line with the principles of sustainable development.

Students as the current generation are required to have sufficient knowledge and skills to decide to act in a way that supports sustainable development, namely thinking about sustainable communities, one of which is improving systems thinking skills, thus it is expected that students are ready to enter 21st century education (Clark et al., 2017; Zubaidah, 2020). Categorizing technology usage strategies (e.g., providing authentic contexts, offering web-based inquiry environments, using interactive and immersive technologies, and creating content). Nurtanto et al. (2020) can help educators adopt effective strategies to support and guide student learning in STEM-Engineering Design Process (EDP) education, potentially enabling students to develop high-level system thinking skills and creativity in problem solving. The use of technology in STEM-Engineering Design Process (EDP) education can expand the effectiveness of the teaching and learning process (Mohammad et al., 2021) beyond what is possible with traditional teaching methods (Deke et al., 2022).

The STEM approach is a learning process that can be designed to provide a learning atmosphere that can increase knowledge, motivation, creativity, and new innovations. Other research results according to Sole (2021), show that STEM has the potential to make students play a role in problem solving, inventors, innovators, and have an awareness of the benefits of technology, and are able to think logically.

Engineering Design Process (EDP) integrated with STEM. PjBL-STEM combined with engineering design process (EDP) is described as an educational system that places mathematical knowledge in the context of design technology to create a problem-solving learning environment where students imagine solutions to designs, gather information, and solve real problems (Wahono et al., 2020). This is in accordance with the results of research conducted by Putra et al. (2023) that EDP can invite students to solve real-world problems with activities designed like an engineer (Putra et al., 2023), but learning using EDP has not been popularly applied in Indonesia, especially in renewable energy materials.

The ability to think systems directs students to be able to think outside the mechanistic and reductionist paradigms that see a phenomenon through the analysis of its constituent parts separately or think out of the box. Systems thinking is very important to be used to understand the pattern of motion of the universe and the living things in it. In learning science, systems thinking emerged as a reaction to the difficulties of science in dealing with various problems in complex systems. For biological researchers, systems thinking is the basic conceptual framework that underlies everyday work and dynamic living systems (Arnold, 2005).

The complexity of systems thinking does not only appear in science, but also in human life as the ability to manage that complexity, which is a way to direct changes in the world for the better Science education emphasizes environmental and environmental issues in science curriculum. Thus, each student seeks to develop environmentally responsible behavior as an introduction to the scientific understanding of the physical environment such as recycling or cleaning the schoolyard. Better familiarization with environmental issues alone is not enough for students to develop decision-making abilities in good systems thinking about environmental issues.

Observations on science education in schools reveal that junior high school students may have little experience of thinking about simple new systems Thus, previous research revealed that teachers need to consider the types of activities such as facilitating students' systems thinking that arise in real-world contexts. In addition, the teacher demonstrates environmental care behavior by learning specific and holistic knowledge that guides learning about the environment. Teachers need to prepare students for the future by involving them in the process of constructing concepts in their minds (Gilbert et al., 2021).

Integration of renewable energy material into the school curriculum is carried out as an effort to overcome the problem of energy availability in Indonesia, which is one of the goals of Education for Sustainable Development (ESD). This is shown by the results of research conducted by Clarisa et al. (2020) that ESD can increase student awareness. Renewable energy material is expected to be easier for students to understand if it is related to the surrounding environment.

Therefore, the main aim of science education in schools should be to equip students with the systems thinking skills needed to understand environmental problems, For example, consider batteries. Batteries are a flexible energy source that can be used anywhere and anytime. With the rapid advancement of technology, the demand for batteries in daily life has increased significantly. Batteries can be found in TV and air conditioner remotes, flashlights, children's toys, radios, wall and wristwatches, and more. Although batteries are not considered a renewable energy source, innovations such as rechargeable chargers and rechargeable batteries have been developed to reduce battery waste. However, because batteries store non-renewable energy, there will come a time when the energy will deplete and eventually run out. Additionally, batteries contain

heavy metals such as mercury, lead, cadmium, and nickel (Gurning et al., 2021).

These components can lead to environmental pollution if battery waste is not disposed of properly. Such waste is classified as hazardous and toxic (B3) and is difficult for microbes to decompose, making it highly dangerous (Ernawati et al., 2019). In Indonesia, banana peel waste is generally not utilized effectively. It is mainly used as organic fertilizer or animal feed. However, banana peels contain a complete range of nutrients such as carbohydrates, protein, fats, potassium, phosphorus, iron, vitamin C, vitamin B, and water. These elements can be used as a source of energy and antibodies for the human body.

The aim of this research is to help reduce the impact of banana and battery waste and to provide a more environmentally friendly energy alternative. Based on the results of the teacher interviews, 66.7% indicated that alternative energy is very much needed in daily life. The purpose of alternative energy is to maintain the environment in which it is used to keep it healthy. Consistent with previous research by Assaraf et al. (2005), students who understand sustainable system thinking towards the environment and the processes occurring within it may have better tools to evaluate changes and potentially know how to live peacefully with environmental awareness. The issue is that a better introduction to environmental problems alone is not sufficient for students to develop effective decision-making skills in system thinking about environmental issues (Nurmalina, 2017).

The results of the preliminary study using a Google Form questionnaire indicate that only 55.6% of teachers use e-LKPD teaching materials. This is because teachers have not yet implemented system thinking-oriented instruction, as they are not familiar with continuous thinking methods and have not obtained appropriate strategies, approaches, and teaching materials for application. Systematic thinking in science education is characterized by the ability to relate one concept to another; however, instruction in schools has not facilitated training for this skill. Most school instruction is primarily focused on textbooks. Ineffective teaching materials lead teachers to use methods that tend to be conventional. One of the most essential teaching materials for teachers and students in the learning process is e-LKPD (Syafitri et al., 2020).

The advantages of e-LKPD include its ability to simplify and narrow down both space and time, making learning more effective. Additionally, e-LKPD can be an engaging tool when students' interest in learning wanes. By using e-LKPD, teachers do not need to conduct face-to-face instruction, as e-LKPD contains systematically designed and easily understandable instructional materials, methods, problem constraints, and evaluations, allowing students to study independently in line with the Merdeka Learning curriculum.

Teachers prepare students to face future challenges by involving them in the process of building concepts in their minds during school learning. The main goal of science education in schools is to equip students with technology-based learning using e-LKPD. Additionally, students should understand renewable energy concepts, moving beyond rote memorization to learning how to utilize renewable energy in their daily lives. Therefore, this study aims to develop STEM-EDP-based e-LKPD to train system thinking skills and creative problem-solving skills.

The novelty of this research lies in the integration of the STEM-Engineering Design Process (EDP) approach in the development of e-LKPD (electronic student worksheets) aimed at enhancing students' system thinking skills and creative problem-solving skills. This study provides new insights into how teachers perceive and assess the effectiveness of STEM-EDP-based e-LKPD in the context of physics education, particularly on the topic of renewable energy.

Through a mixed-methods approach, this research not only collects quantitative data on the use of e-LKPD but also qualitative data that delves into teachers' perceptions, allowing for a deeper understanding of the challenges and opportunities in its implementation. Additionally, the focus on developing system thinking skills and creative problem-solving skills is an important aspect often overlooked in conventional teaching materials, making this research a significant contribution to more innovative and effective educational practices.

Method

This study uses a mixed-methods approach, specifically a Sequential Explanatory Design strategy, which combines both qualitative and quantitative data collection and analysis. The research is conducted in junior high schools (SMP/MTs) in Lampung, Indonesia. The subjects of the study are three science teachers. Data were collected through interviews with the teachers to understand their perceptions of the STEM-EDP-based e-LKPD teaching materials used during the learning process. The interviews addressed two aspects: system thinking skills and creative problem solving. In the preliminary study, a Google Form was used to gather information about the teaching approaches employed and to analyze the e-LKPD materials used by the teachers during instruction.

The questionnaire was designed to cover two aspects: system thinking and creative problem solving,

as well as STEM-EDP-based e-LKPD teaching materials. An analysis was then conducted on the results of the needs assessment questionnaires for teachers and students, presented in percentage form, and subsequently interpreted qualitatively. The questionnaire utilized a Guttman scale with response options of "Yes" and "No," scored as "1" and "0" respectively. The results were analyzed using the percentage of responses for each item, and the interpretation of the respondents' answers was presented in descriptive narrative form, categorized as very good, good, fair, and poor.

The results of the questionnaire were analyzed using the percentage of responses for each item. Both studies share the same priority, involving triangulation and integration. The schematic design of the research is illustrated in the following figure.

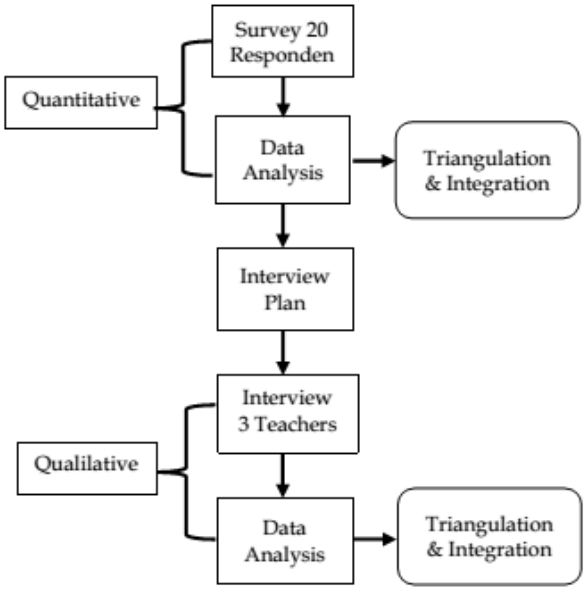

Figure 1. The research design schematic

Figure 1 is a schematic research design in sequential research stages, starting with qualitative research and continuing with quantitative research that follows the sequential explanatory design stage (Shorten, 2017). The collection and analysis of qualitative data was carried out at an early stage. Building on the results of the exploratory analysis in the first stage. Then proceed to the next stage with quantitative methods (a survey of 20 respondents) to test or make generalizations based on the initial findings and interpret how the results of qualitative research are built with initial findings (interviews with 3 teachers). Build an instrument based on findings at an early stage to obtain overall prevalence in a larger sample. Data analysis in quantitative and qualitative analysis was carried out in an integrated and triangulated.

Result and Discussion

This preliminary study aims to determine the needs of teachers and students regarding the development of STEM-EDP-based e-LKPD (electronic Student Worksheets) on the topic of renewable energy. The research was conducted by distributing a questionnaire in the form of a Google Form to physics education teachers in Lampung Province. This study presents an investigation into the needs and perceptions related to renewable energy in the development of physics learning. Our analysis aims to identify the needs of teachers and students by examining the number of completed questionnaires. The information collected from the questionnaire, which pertains to STEM-EDP-based e-LKPD designed to enhance system thinking skills and creative problem-solving skills, is presented in the table 1. Teachers' understanding of learning using STEM-EDP-based e-LKPD teaching materials:

Table 1. Results of Teacher Perception Questionnaire Interpretation

Quation	Percentage (%)	
	Yes	No
Teachers' understanding of learning using STEM-EDP-based e-LKPD teaching materials	34.8%	65.2%
Teacher's understanding of systems thinking skills	11.1%	88.9%
The teacher's way of applying systems thinking skills during learning	19.9%	80.1%
Use of teaching materials that improve systems thinking skills	72.2%	27.8%
Teachers' understanding of creative problem solving skills	77.8%	22.2%
How teachers apply creative problem-solving skills during instruction	27.8%	72.2%
Teachers' understanding of renewable energy	83.3%	16.7%
Classroom implementation using e-LKPD materials to train system thinking skills and creative problem solving	33.3%	66.7%

Based on the responses from teachers, it was found that 65.2% have not implemented STEM-EDP-based e-LKPD learning, while 34.8% are familiar with and have incorporated it into their teaching. These results indicate a knowledge gap among teachers regarding STEM-EDP-based e-LKPD teaching materials. The majority of teachers who are not familiar with STEM-EDP demonstrate a lack of exposure or training related to this approach. STEM-EDP is important because it connects science with social issues, helping students develop

critical and analytical thinking skills. Teachers who are not familiar with STEM-EDP tend to use conventional methods that are less relevant to real-world contexts, while those who have implemented it report increased student engagement. To address this gap, further training for teachers on integrating scientific issues into their teaching is necessary.

The results of teachers' perceptions regarding learning strategies using e-LKPD to develop system thinking skills show that only 11.1% of teachers are employing methods that foster these skills, while 88.9% have not demonstrated approaches that can develop system thinking skills. This situation arises because even teachers who are aware of system thinking indicators still face challenges. Effective system thinking in science education involves linking one concept to another; however, the instruction provided often focuses on a single concept without relating it to others. Ineffective teaching materials lead teachers to use conventional methods. This is supported by research findings, which indicate that 66.7% of teachers have not used STEM-EDP-based e-LKPD materials, while 33.3% of teachers use printed modules obtained by downloading from the internet. Teachers need teaching materials that can enhance system thinking skills.

The results of teachers' perceptions regarding renewable energy show that 83.3% of teachers are aware of the importance of renewable energy in daily life. However, 16.7% of teachers are not familiar with it due to a lack of training information, particularly for teachers in rural areas. In the current digital technology era, e-learning has been rapidly advancing. E-learning involves learning through electronic resources and supports interactive remote learning. The available information can be accessed via web systems without being constrained by space and time. Therefore, 66.7% of teachers need electronic-based teaching materials that can be accessed online. A teacher can prepare students for better learning processes and improve educational outcomes, encouraging active student participation in knowledge sharing, which helps develop system thinking skills and creative problem solving skills.

Table 2. Teachers' Questions and Answers

Question	Teacher's Response
What are the thinking skills of a sustainable community?	• Moving towards a better future for society • Critical thinking • Creative thinking • Mindset related to traditions, knowledge, and technology • Efforts to empower communities through human resource development, environmental conservation technologies, and other awareness initiatives
What is systems thinking ability?	• Systems thinking is a person's ability to think in a structured and global way • Ability to look at the problem as a whole • Understanding things in a different way (not just from one side only)
How do you improve systems thinking skills in science learning?	• Not yet, because I don't really understand how to apply systems thinking • Haven't found the right approach • Discovery learning models, scientific approaches, and methods of discussion, question and answer and recitation.
What are creative problem solving skills?	• Creative problem solving is the ability to find innovative and effective solutions to various challenges or problems.
What is STEM-EDP?	• STEM-EDP refers to a concept that combines STEM (Science, Technology, Engineering, and Mathematics) principles with the Engineering Design Process (EDP)
What teaching materials have you used so far?	• Module • LKPD • Internet sources
How do you get to modules in science learning?	• Downloading from internet • Teacher's book • Buy at publisher
Can the modules you have been using improve students' systems thinking and creative problem solving skills?	• Lack of understanding of making modules that can improve students' systems thinking skills and creative problem solving skills • More to improve mastery of concepts
In your opinion, do you need e-LKPD based on STEM-EDP to train system thinking skills and creative problem solving skills?	• I think it is necessary, because as part of the variation in teaching so that students are not too bored to take part in learning

Question	Teacher's Response
	• So that students in particular and educators are ready to face the challenges of 21st century learning

Based on the description above, it can be concluded that the use of technology in learning is in the form of electronic modules (e-LKPD) based on STEM-EDP on science material that is close to the context of everyday life, namely renewable energy. STEM-EDP stands for Science, Technology, Engineering, and Mathematics - Engineering Design Process. It refers to an educational approach that integrates science, technology, engineering, and mathematics through the engineering design process. In this context, students are encouraged to solve real-world problems using engineering methods, which include steps such as defining the problem, designing solutions, building, testing, and refining. This approach aims to enhance students' conceptual understanding and practical skills in contexts relevant to everyday life.

The goals of STEM-EDP are to develop problem-solving skills, enhance conceptual understanding, and encourage collaboration among students. Through this approach, students are invited to think critically and creatively in solving real-world problems while building relevant technology and engineering skills for the workforce. Additionally, STEM-EDP aims to foster students' interest in careers in science, technology, engineering, and mathematics, as well as to connect learning with everyday life and global issues, ultimately producing individuals who are prepared to face future challenges. The following is a design of STEM-EDP steps in learning.

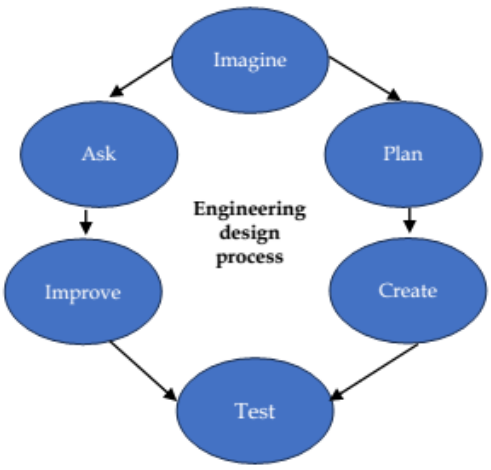

Figure 2. EDP stages

The Engineering Design Process (EDP) is a pedagogical approach applied to students (Tipmontiane et al., 2021). In the Engineering Design Process, it not only generates abstract concepts but also applies design skills to students through problem-solving approaches and foundational concepts (Moore et al., 2014). Therefore, EDP plays a crucial role in educational learning by helping students solve problems through concepts related to everyday life. One way to apply e-learning strategies and models is by developing electronic learning materials, such as electronic modules or e-LKPD. Learning in the form of electronic modules or e-LKPD is educational content that is designed in a structured manner based on the curriculum and organized within a specific timeframe. It is packaged using electronic devices such as computers or smartphones, making the learning process more effective, practical, and capable of enhancing knowledge and additional skills for both teachers and students (Alfrado et al., 2024).

Effective, practical, and capable of enhancing knowledge and additional skills for both teachers and students (Ramadhani et al., 2019). STEM-EDP integration materials, through simple YouTube videos containing information about tools, enable students to correctly understand the use of household waste. Students can systematically design experimental procedures for household waste, such as using banana peels to create renewable energy in the form of bio-batteries. They can also describe the design of simple tools for household waste based on literature and measure accurately in the creation of these tools (Yulianti et al., 2020). This aligns with multimedia cognitive theory (Sari et al., 2020), which explains that students have two channels for processing information: visual and verbal. This means that each person has separate and distinct communication channels, so different types of information should be presented through appropriate media.

This is also consistent with multimedia learning, where students are expected to have control over their own learning pace according to their individual abilities. Additionally, multimedia learning helps students become more independent in understanding the material. Multimedia cognitive theory explains that students have two channels for processing information: visual and verbal (Rahmah, 2018). This means that each person has separate communication channels, so different types of information should be presented through appropriate media to ensure that the learning process is maximized.

Therefore, learning materials in the form of e-LKPD will help students understand the lesson content. This aligns with previous research, such as the development of e-modules for Science subjects on the topic of interactions between living organisms and their

environment. Teachers use these materials as homework for students (Rachman, 2018). During classroom instruction, students should pay attention to the teacher. Learning that is significantly related to e-learning concepts can be implemented through science-based project modules, combined with a STEM approach. This enables students to explore Science, Mathematics, and Engineering by addressing real world problems.

Conclusion

The survey results indicate that 77.8% of teachers use the STEM model for teaching, but only 72.2% of students are engaged in setting goals and defining problems. Teachers have a positive perception of e-LKPD based on STEM-EDP for enhancing system thinking skills and creative problem-solving skills. However, most teachers have not adopted this approach. STEM-EDP trains students in scientific understanding, mathematical skills, and conceptual understanding in science. Learning through this e-LKPD can support the independent curriculum and encourage active student engagement in the learning process.

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Author Contributions
The contributions of A.A. and K.H. in the writing include providing an overview of Renewable Energy in everyday life. A.A.'s contribution specifically offers a profile of STEM-EDP along with the challenges in physics education, particularly regarding the topic of renewable energy, as well as the lack of learning activities that can stimulate students' system thinking skills and creative problem-solving abilities.

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Conflicts of Interest
There are no conflicts of interest.

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