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# NEEDS ANALYSIS FOR THE DEVELOPMENT OF STEM-BASED INTERACTIVE LEARNING MEDIA ON RENEWABLE ENERGY MATERIALS - MICRO HYDRO POWER PLANTS FOR HIGH SCHOOL STUDENTS

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## *Abstract*
*Learning physics related to renewable energy, mainly Micro Hydro Power Plants (PLTMH), is often considered difficult due to its abstract, theoretical nature and lack of visualization. This condition makes it difficult for students to understand the concepts and connect them to real life. This study aims to obtain preliminary data to develop an initial design for STEM-based interactive learning media on renewable energy (PLTMH) for high school students. The method used is qualitative descriptive research, combining literature and field studies. The field study was conducted at SMA Negeri 1 Kikim Selatan, involving two physics teachers and 119 tenth-grade students. Data were obtained through questionnaires and analyzed using data reduction, data presentation, and conclusion drawing techniques. The results showed that PLTMH material was dominated by abstract concepts and processes that could lead to misconceptions without concrete examples. Teachers considered the existing media helpful but limited, while students found the material challenging to understand, too theoretical, and not relevant to real life. Teachers and 91.6% of students supported the development of STEM-based interactive media because it was considered adequate for visualizing concepts and increasing student engagement. These findings emphasize the need to develop such media to bridge the gap between physics theory and its application in the context of real renewable energy.*

***Keywords**: Needs Analysis, Renewable Energy, Interactive Learning Media, PLTMH, STEM.*

## *Abstrak*
*Pembelajaran fisika pada materi energi terbarukan, khususnya Pembangkit Listrik Tenaga Mikrohidro (PLTMH), sering dianggap sulit karena sifatnya abstrak, teoritis, dan minim visualisasi. Kondisi ini menyebabkan siswa kesulitan memahami konsep serta kurang mampu mengaitkannya dengan kehidupan nyata. Penelitian ini bertujuan untuk memperoleh data awal sebagai dasar dalam penyusunan rancangan awal media pembelajaran interaktif berbasis STEM pada materi energi terbarukan (PLTMH) siswa SMA. Metode yang digunakan adalah penelitian deskriptif kualitatif melalui studi literatur dan studi lapangan. Studi lapangan dilakukan di SMA Negeri 1 Kikim Selatan dengan melibatkan 2 guru fisika dan 119 siswa kelas X. Data diperoleh melalui angket dan dianalisis dengan teknik reduksi data, penyajian data, serta penarikan kesimpulan. Hasil penelitian menunjukkan bahwa materi PLTMH didominasi konsep abstrak dan proses yang berpotensi menimbulkan miskonsepsi tanpa adanya contoh konkret. Guru menilai media yang ada cukup membantu namun masih terbatas, sementara siswa menilai materi sulit dipahami, terlalu teoritis, dan kurang terkait dengan kehidupan nyata. Guru dan 91,6% siswa mendukung pengembangan media interaktif berbasis STEM karena dinilai efektif untuk memvisualisasikan konsep dan meningkatkan keterlibatan siswa. Temuan ini menegaskan perlunya pengembangan media tersebut untuk menjembatani kesenjangan antara teori fisika dan penerapannya dalam konteks energi terbarukan yang nyata.*

***Kata Kunci**: Analisis Kebutuhan, Energi Terbarukan, Media Pembelajaran Interaktif, PLTMH, STEM.*

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## INTRODUCTION

The development of science and technology in the 21st Century demands transformation in the world of education, particularly in science education. Science education plays a vital role in the development of individuals and society as a whole (Yunita & Mandasari, 2025). Science education is now being developed with a focus on strengthening 21st-century skills, namely critical, creative, collaborative, and communicative thinking (Makmuri & Harun, 2024). 21st-century skills play an important role in equipping individuals to navigate the dynamics of the 4.0 industrial revolution and survive amid global competition (Faiza & Wardhani, 2024). The rapid development of science and technology demands a transformation in education toward a more applied, engaging approach to enhance the quality of learning (Fadhilah et al., 2023). To achieve this goal, science education must be designed in a contextually and innovatively way that connects scientific concepts to real-world applications.

Physics is one of the main foundations of the natural sciences (IPA), focusing on the study of various natural phenomena and the principles underlying them (Magfirah, 2024). In physics learning, students are expected not only to understand theoretical concepts but also to relate them to everyday applications (Pilendia, 2024). However, the reality is that physics learning is often less interactive and places too much emphasis on memorizing formulas (Wafa et al., 2025). As a result, students tend to play a passive role, merely absorbing information without engaging in interaction or meaning-making, rather than being active learners capable of generating innovative ideas (Sahra et al., 2025). This phenomenon indicates a gap between the demands of 21st-century education and classroom learning practices.

One physics topic that is highly relevant to daily life and global issues is renewable energy. One concept of renewable energy commonly used in daily life is hydropower (Lima et al., 2023). Water has now evolved from a mere basic resource to a renewable energy source for generating electricity (Elo & Syahdinar, 2023). Indonesia has great potential for the utilization of water energy sources, one of which is Micro-Hydropower Plants (PLTMH) (Rahayu & Windarta, 2025). Micro-Hydropower Plants (PLTMH) are energy generation systems that utilize water flow to produce mechanical energy through turbines, which is then converted into electrical energy by generators (Ardo et al., 2022). The electricity generation process in PLTMH is determined by gravitational potential energy and flow rate (Dwipayana et al., 2023). This material is closely related to physics concepts such as the law of conservation of energy, energy transformation, and fluid mechanics.

Given field realities, the process of learning about renewable energy materials still faces various obstacles. Renewable energy materials are often considered difficult by students because they cover physics concepts that require real visualization and direct relevance to everyday life (Naufal et al., 2024). The lack of concrete, interactive learning materials makes it difficult for students to imagine how water flow can be converted into electrical energy. As a result, students' understanding tends to be superficial, less applicable, and challenging to retain in the long term.

To address these challenges, updates are needed through the design of learning media that can create contextual and meaningful learning experiences for students. Using educational media can enrich the learning process, thereby improving the quality of student education (Wiyono et al., 2024). Engaging learning media are essential for building interest in learning and strengthening students' thinking skills (Hidayati et al., 2023). One approach considered adequate is STEM (Science, Technology, Engineering, and Mathematics)- based learning (Abas et al., 2024). The STEM approach integrates the disciplines of science, technology, engineering, and mathematics to equip students with creativity through problem-solving processes in life (Subayani et al., 2022). The integration of scientific disciplines in STEM helps students

understand physics concepts more comprehensively and relate them to real-life situations, thereby deepening the process of concept internalization (Hayat, 2024).

Before developing this STEM-based interactive learning media, it is necessary to conduct a needs analysis as a preliminary study to gather data and information, both through literature and field studies, so that the resulting media is truly aligned with the learning context in schools. The literature study examined the high school physics curriculum and the relevance of renewable energy concepts, particularly PLTMH, to the competencies that must be achieved. Meanwhile, the field study gathered information on students' and teachers' needs in the learning process, particularly regarding the limitations of available media and students' difficulties in understanding the material. The results of this needs analysis are expected to form the basis for a draft of contextual, applicable STEM-based interactive learning media.

## METHODS

This research is a qualitative descriptive study that aims to analyze needs as a basis for developing STEM-based interactive learning media. The research was conducted at SMA Negeri 1 Kikim Selatan, Lahat Regency, South Sumatra Province in the 2025/2026 academic year. The research subjects were two physics teachers and 119 tenth-grade students who had studied renewable energy material. The needs analysis was based on the results of initial data collection from a literature review and a field study. The literature study examined various concepts in renewable energy materials, while the field study distributed questionnaires via *Google Forms.* The data obtained was then processed using qualitative analysis with the stages of data reduction, data presentation, verification, and conclusion drawing.

## RESULTS AND DISCUSSION

Needs analysis, as the basis for developing STEM-based interactive learning media on renewable energy materials (PLTMH) for high school students, is the initial stage of the development process. The study's results examine several aspects, including an analysis of learning materials and a needs analysis informed by teachers' and students' perspectives.

### A. Material analysis

Material analysis was conducted through a literature review of the Grade 10 Physics textbook for semester 2 used at SMA Negeri 1 Kikim Selatan, based on the Merdeka curriculum, to examine the concept of renewable energy, specifically the topic of Micro Hydro Power Plants (PLTMH). This study analyzed concepts related to renewable energy materials using the concept analysis method developed by Herron (in Tsaparlis & Kampourakis, 2000). This method classifies concepts into eight (8) categories, namely: (1) concrete concepts, (2) abstract concepts, (3) abstract concepts with concrete examples, (4) concepts based on principles, (5) concepts that express symbols, (6) concepts that express process names, (7) concepts that express properties and attribute names, (8) concepts that express attribute measurements. The analysis of renewable energy-PLTMH concepts is presented in Table 1.

**Table 1.** Concept Analysis of Renewable Energy-PLTMH Material

| No | Concept | Concept Definition | Concept Type |
|---|---|---|---|
| 1 | Energy | The ability to perform work or effort. | Concrete |
| 2 | Kinetic Energy | Energy possessed by an object due to its motion. | Abstract concept with concrete examples |
| 3 | Gravitational Potential Energy | The energy possessed by an object is due to its position relative to the Earth's surface. | Abstract concept with concrete examples |
| 4 | Mechanical Energy | The sum of potential energy and kinetic energy. | Concept based on the principle |
| 5 | Electrical Energy | The flow of electric charge generates energy. | Abstract concept with concrete examples |
| 6 | Law of Conservation of Energy | Energy is conserved, meaning that energy cannot be created or destroyed; it can only change form. | Concept based on principle |
| 7 | Energy Conversion | The process of changing energy from one form to another | Concept that describes the process |
| 8 | Energy Source | Anything that can produce energy for human needs. | Concepts that describe the properties and names of attributes |
| 9 | Renewable Energy | Energy that can be naturally replenished and will never be exhausted. | Concepts that describe the nature and names of attributes |
| 10 | Impact of Energy Use | The influence of energy utilization on the environment and society | Concepts that describe processes |
| 11 | Efforts to Meet Energy Needs | Strategies for meeting energy needs in a sustainable manner | Concepts that describe the process |
| 12 | PLTMH (Micro-Hydro Power Plant) | A small-scale power plant that utilizes water energy. | Concrete |

**Results of the Analysis of the Concept of Renewable Energy Materials-PLTMH**

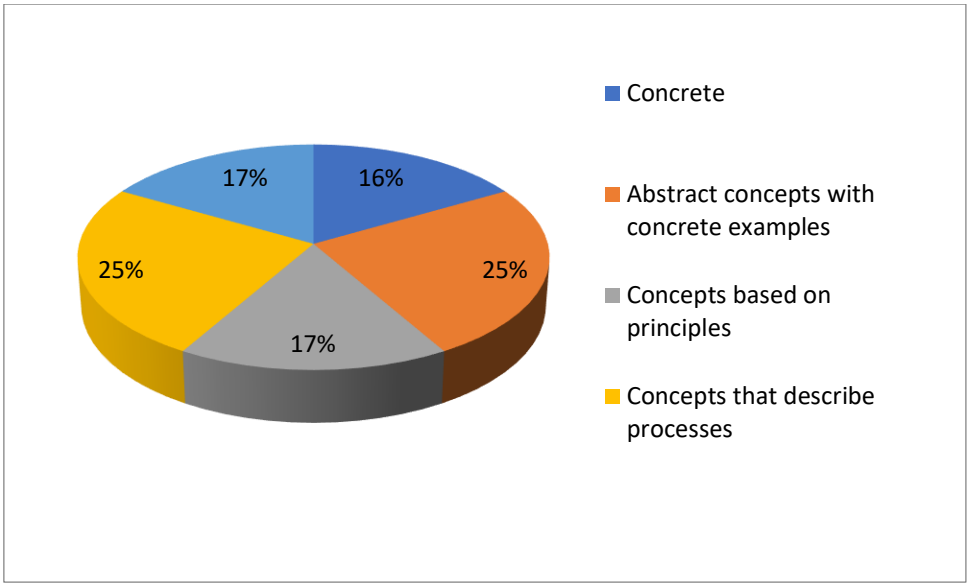


**Figure 1.** Diagram of the Analysis Results of the Renewable Energy-PLTMH Concept Material

Based on the analysis of the concept of renewable energy-PLTMH, it was found that renewable energy materials on the topic of PLTMH can serve as a basis for the development of STEM-based interactive learning media. It was found that the concept of renewable energy-PLTMH is divided into five categories, namely: (1) concrete concepts amounting to 16%, (2) abstract concepts with concrete examples amounting to 25%, (3) concepts based on principles (17%), (4) concepts that describe processes (25%), and (5) concepts that describe properties and attributes (17%). The analysis shows that the dominant concepts are those that describe processes and abstract concepts with concrete examples, each accounting for 25%. The dominance of these two concepts indicates that students need to understand the mechanism of energy change and its application in real life. However, a significant portion of abstract concepts (such as mechanical energy, potential energy, and the law of conservation of energy) can lead to misconceptions if not illustrated with concrete examples.

The practical implication of this finding is the importance of developing STEM-based interactive learning media that bridge students' understanding by presenting process visualizations, interactive simulations, and concrete examples from everyday life. For instance, on the topic of micro-hydro power plants, students can be invited to observe the energy conversion from water to electricity through an animation. With this approach, abstract concepts will be easier to understand, misconceptions can be minimized, and renewable energy material will become more meaningful and contextual.

## B. Analysis of teacher and student needs

The next stage involves analyzing the needs of teachers and students regarding the use of media in physics learning activities, particularly in the subject of renewable energy-PLTMH. This analysis begins by distributing questionnaires via *Google Forms* to teachers and students to obtain an overview of classroom conditions, the availability of learning facilities, and the obstacles to understanding the material. The researcher conducted a field study at SMA Negeri 1 Kikim Selatan, involving two physics teachers and 119 tenth-grade students as respondents. This analysis aimed to

determine the urgency of developing STEM-based interactive learning media on renewable energy-PLTMH material.

**Table 2.** Analysis of Teachers' Needs for Interactive Learning Media

| No | Problem Identification | Answer | Conclusion of Identification |
|---|---|---|---|
| 1 | Are you a physics teacher who has taught Renewable Energy at SMA N 1 Kikim Selatan? | All respondents answered "Yes." | Teachers have taught renewable energy material. |
| 2 | What media do you usually use to teach renewable energy material? | The media used include educational videos and real teaching aids such as solar panels. | Teachers use simple media, such as videos and real teaching aids. |
| 3 | How effective have the media you have used so far been in explaining renewable energy material? | The media is considered adequate, though its impact remains limited. | The media is quite effective in explaining renewable energy materials, but it still has limitations. |
| 4 | What difficulties do students most often experience in understanding renewable energy material? | The main difficulty is that the material is too theoretical and lacks visualization. | Students struggle because the material is abstract and lacks visual aids. |
| 5 | Can STEM-based interactive media help students understand renewable energy material (especially PLTMH)? | STEM-based interactive media is considered very helpful. | STEM-based interactive media is highly effective at improving students' understanding. |
| 6 | Is it essential to relate renewable energy material to students' daily lives? | Teachers consider it essential to form energy-saving habits and raise students' awareness. | Linking the material to everyday life is considered very important for students. |
| 7 | Do you agree with the development of STEM-based interactive media for renewable energy material—PLTMH? | All respondents agree. | Teachers support the development of STEM-based interactive media for renewable energy materials. |
| 8 | How important is the development of interactive STEM-based media for renewable energy materials—PLTMH? | All respondents rated it as very important. | The development of STEM-based interactive media is considered very important. |
| 9 | Expectations for the future development of interactive STEM-based learning media. | The expectation is that interactive, enjoyable learning will be created, making it easier for students to understand the material. | Interactive media is expected to create an engaging learning environment and facilitate student understanding. |

Based on the analysis of teachers' needs for interactive STEM-based learning media on renewable energy PLTMH materials for high school students, several significant findings emerged. First, teachers have previously taught renewable energy material in physics lessons. The learning media used so far are still simple, such as educational videos and solar panels as teaching aids. Although these media are considered quite effective, they still fall short in explaining complex renewable energy concepts. One of the main difficulties students face is the tendency for the material to be too theoretical and lack visual aids, so students' understanding is not yet optimal.

Teachers believe that STEM-based interactive learning media are highly needed, as they facilitate a deeper understanding of the material and encourage active participation in the learning process. In addition, linking renewable energy material to everyday life is considered necessary so that students have awareness and concern for the use of alternative energy. Teachers' support for the development of STEM-based interactive media is also strong, with the hope that such media will create interactive, enjoyable, and easy-to-understand learning experiences that foster students' enthusiasm for learning.

Overall, the results of this analysis show that the development of STEM-based interactive learning media on renewable energy material is a real need. These media are not only expected to overcome the limitations of learning facilities and the variety of media, but also to create meaningful learning experiences by connecting scientific concepts in the material to real situations students experience.

**Table 3.** Analysis of Student Needs for Interactive Learning Media

| No | Question | Response | Percentage |
|---|---|---|---|
| 1 | Do you have ICT (information and communication technology) devices at school? (e.g., laptop, tablet, computer, or cell phone) | Yes | 100% |
| | | No | 0% |
| 2 | What devices do teachers commonly use in physics lessons at your school? *(You may select more than one)* | Smartphone/Mobile phone | 68.1% |
| | | Laptop | 45.4% |
| | | Tablet | 7.6% |
| | | Computer | 31.1% |
| | | Projector | 30.3% |
| 3 | How is the quality of the internet connection at your school and home? | 5G | 2.5% |
| | | 4G | 94.1% |
| | | 3G | 2.5% |
| | | 2G | 0.8% |
| 4 | Have you ever studied renewable energy? | Yes | 100% |
| | | No | 0% |
| 5 | To what extent is the renewable energy material taught related to real life or the environment? | Very relevant | 0.8% |
| | | Somewhat relevant | 0% |
| | | Less | 26.1% |
| | | Not Related | 73.1% |
| 6 | Have you ever studied physics using a STEM-based approach? | Yes | 80.7% |
| | | No | 4.2% |
| | | Not sure | 15.1% |
| 7 | In your opinion, will STEM-based interactive media help in understanding Renewable Energy | Very helpful | 66.4% |
| | | Helpful | 33.6% |
| | | Neutral | 0% |

| | | | |
|---|---|---|---|
| | material, specifically PLTMH? | Not helpful | 0% |
| 8 | What difficulties do you often encounter when studying renewable energy materials? *(You may select more than one)* | Difficult to understand | 81.5% |
| | | Not interesting | 6.7% |
| | | Too Theoretical | 31.9% |
| | | Lacks Visualization | 24.4% |
| 9 | Do you agree that interactive STEM-based media should be developed for renewable energy materials, especially PLTMH? | Yes | 91.6% |
| | | No | 8.4% |

Based on the survey results, all students (100%) have ICT devices, with the majority using smartphones (68.1%) and laptops (45.4%). This shows that, in terms of device availability, students are ready to use interactive learning media. In addition, the majority of students have 4G internet connectivity (94.1%), indicating that online interactive press is likely to be accessible to students. This condition refers to the readiness of the basic infrastructure to support the implementation of technology-based learning media.

Although all students (100%) reported studying renewable energy materials, their perception of the materials' relevance to their daily lives remained low. As many as 73.1% of students considered the material irrelevant, 26.1% less relevant, and only 0.8% very relevant. These findings indicate a gap between the theoretical concepts studied and the realities students experience. Thus, the learning media developed need to integrate real contexts, such as examples of Micro Hydro Power Plants (PLTMH) in Indonesia, so that students can understand the relevance of the material in their daily lives.

In terms of approach, most students (80.7%) reported studying using a STEM-based approach, although a small number (15.1%) were unsure, and 4.2% had never learned this way. This shows that students are relatively familiar with the STEM approach, so developing interactive media using it will not feel unfamiliar and can deepen their learning experience.

Students' responses to the role of STEM-based interactive media were also positive: 66.4% found it beneficial, and 33.6% found it helpful in understanding renewable energy materials. However, students also identified several difficulties in learning, such as material that is difficult to understand (81.5%), too theoretical (31.9%), uninteresting (6.7%), and lacking in visualization (24.4%). This data reinforces the urgency to provide interactive learning media that is not only informative but also interesting, applicable, and capable of visualizing abstract concepts more tangibly.

Furthermore, most students (91.6%) agreed that STEM-based interactive media should be developed for renewable energy materials, especially PLTMH. This high percentage reflects strong student support for learning media innovation. Thus, the development of STEM-based interactive media on renewable energy materials is not only feasible but also justified by students' real needs.

## CONCLUSION

This study shows that physics learning on renewable energy materials, especially PLTMH, still faces obstacles due to its abstract nature, overly theoretical approach, and lack of visualization. The needs analysis reveals that both teachers and students need interactive STEM-based learning media. Teachers consider the existing media helpful but limited, while students feel the material is not relevant to real life and challenging to understand without visualization. The results of the concept analysis indicate that the dominance of abstract concepts and processes in PLTMH material

requires media that offer concrete examples, simulations, and visualizations. Thus, the development of interactive STEM-based learning media on renewable energy materials PLTMH is significant for bridging the gap between theoretical concepts and their application in everyday life.

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