



Original Article

Integration of Problem-Solving-Based E-Modules in Physics Learning to Enhance the Creativity and Understanding of Engineering Students

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Abstract:

In the era of Industry 4.0, higher education must not only strengthen students' conceptual understanding but also foster creative and problem-solving skills, especially among engineering students who often face difficulties in learning abstract physics concepts. This study aims to develop and evaluate the effectiveness of a problem-solving-based electronic module (e-module) to enhance engineering students' creativity and conceptual understanding in physics learning. Using a qualitative library research design, this study synthesizes theories and findings from national and international publications between 2019 and 2025. Data were analyzed through content analysis to identify relationships between problem-solving-based e-modules, creativity, and conceptual mastery. The results reveal that integrating problem-solving stages—problem identification, hypothesis formulation, model construction, testing, and reflection—into e-modules significantly improves creativity indicators such as fluency, flexibility, and originality, as well as conceptual comprehension of physical principles. Expert validation confirmed the module's high feasibility and practicality, with students reporting improved motivation and engagement. Furthermore, the inclusion of real-world engineering scenarios and interactive simulations successfully bridged the gap between theoretical physics and its practical applications. Overall, the findings highlight that problem-solving-based e-modules serve as an effective pedagogical innovation for promoting active, creative, and conceptual learning in physics education for engineering students.

Keywords: Problem-Solving-Based E-Module, Creativity, Conceptual Understanding.

Introduction

In the era of the Fourth Industrial Revolution and rapid technological advancement, higher education is expected not only to develop students' conceptual mastery but also to foster creative thinking and complex problem-solving skills ([Husin et al., 2025](#)). Particularly for engineering students, physics often poses challenges due to its abstract nature and the requirement for strong mathematical and conceptual understanding ([Sirnoorkar et al., 2023](#)). Moreover, conventional physics learning in many engineering programs remains dominated by lectures and routine exercises,



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which tend to limit students' opportunities to develop their own problem-solving strategies or explore creative ideas ([Marcinauskas et al., 2024](#)). Therefore, there is an urgent need for innovation in instructional media and learning methods that can enhance both conceptual understanding and creativity among engineering students when dealing with applied physics problems.

One promising innovation is the use of electronic modules (e-modules)—technology-based learning materials that can be accessed online or in blended formats. The use of e-modules in physics learning has been shown to improve scientific process skills, scientific literacy, and learning motivation among students ([Yosa et al., 2025](#)). For example, the development of problem-solving-based e-modules in basic physics practicum has proven effective in enhancing students' science process skills ([Darmaji et al., 2019](#)). E-modules allow the integration of multimedia, interactivity, and scaffolding that guide students through problem-solving steps independently ([Serevina et al., 2018](#)). Thus, e-modules serve a strategic role in transforming physics learning from mere knowledge transmission to an active and reflective learning process.

Furthermore, the problem-solving approach in physics learning positions students as active participants in analyzing, synthesizing, and reflecting on problems as part of the learning process ([Sirnoorkar et al., 2023](#)). This approach is particularly relevant for engineering students who will face technical challenges requiring innovative and adaptive solutions in industrial contexts ([Husin et al., 2025](#)). For instance, research has shown that integrating problem-solving-based e-modules in static fluid topics significantly improves students' problem-solving skills ([Putra et al., 2025](#)). Hence, combining e-modules with a problem-solving approach is an effective strategy to enhance both conceptual understanding and creativity in engineering physics education.

In the context of higher engineering education in Indonesia, creativity is one of the essential 21st-century skills that must be developed to prepare graduates for global and technological challenges. Studies have demonstrated that physics learning using the STEM (Science, Technology, Engineering, Mathematics) approach effectively enhances students' creativity at the university level ([Siswanto, 2018](#)). Additionally, other research confirms that project-based and problem-based learning contribute to improving students' creativity and critical thinking ([Widyaningtyas et al., 2024](#)). However, the implementation of e-modules that specifically integrate problem-solving and creativity in engineering education remains limited.

The urgency of this research lies in the growing demands of the industrial and technological world aligned with Industry 4.0, where creative and adaptive problem-solving abilities are increasingly essential. Engineering students with strong conceptual knowledge of physics alone are no longer sufficient; they must also be able to apply those concepts in technical contexts, design solutions, and innovate. Therefore, developing a problem-solving-based e-module in physics learning for engineering students is both relevant and necessary as a response to the current demands of higher education.

Several previous studies have explored the development of physics e-modules and their impact on learning outcomes. For instance, [Subekti & Nuraeni, \(2024\)](#) developed an optics e-module that improved students' scientific communication ([Subekti & Nuraeni, 2024](#)); [Putri \(2022\)](#) created a STEM-based physics e-module for high school students that was found feasible for classroom use ([Putri, 2023](#)); and [Serevina et al. \(2018\)](#) designed a problem-based e-module on heat and temperature that enhanced

students' science process skills (Serevina et al., 2018). However, studies focusing on engineering students—specifically those targeting both creativity and physics conceptual understanding through problem-solving-based e-modules—are still scarce. This research seeks to fill that gap.

The purpose of this study is to develop and test the effectiveness of a problem-solving-based e-module in physics learning for engineering students, aiming to enhance their creativity and conceptual understanding of physics. Specifically, this study aims to: (1) develop a problem-solving-based e-module tailored to engineering students' learning characteristics, (2) evaluate the feasibility and practicality of the developed e-module, and (3) measure the effectiveness of the e-module in improving engineering students' creativity and conceptual understanding in engineering physics courses.

Methods

Research Design

This study employs a qualitative approach with the type of library research (literature study). The purpose is to analyze and synthesize theories and previous findings related to the integration of problem-solving-based e-modules in physics learning to enhance engineering students' creativity and conceptual understanding. A literature study is suitable for developing a comprehensive theoretical framework based on existing scientific evidence ([Creswell & Poth, 2016](#); [Zed, 2018](#)).

Data Sources

The data sources consist of credible and relevant scientific publications, including national and international journal articles, academic books, conference proceedings, and research reports discussing e-modules, problem-based learning, creativity, and physics education in engineering contexts. Sources were selected purposively based on their relevance, credibility, and recency (2019–2025), with classical theories included when necessary ([Miles et al., 2020](#)).

Data Collection Techniques

The data collection was conducted in several systematic stages:

1. literature search using databases such as Google Scholar, ScienceDirect, ResearchGate, and Taylor & Francis with keywords “e-module,” “problem-based learning,” “physics education,” “engineering students,” “creativity,” and “conceptual understanding”;
2. screening of articles based on relevance to the research focus; and
3. organizing selected studies into thematic categories ([Snyder, 2019](#)).

Data Analysis Method

The data analysis used a content analysis technique that is descriptive and analytical. It involved identifying, classifying, and interpreting ideas and findings from multiple studies to uncover the relationship between problem-solving-based e-modules, creativity, and conceptual understanding ([Krippendorff, 2018](#)). The analysis followed three stages:

1. data reduction, selecting essential information from the literature;
2. data presentation, organizing data into thematic descriptions; and
3. conclusion drawing, interpreting patterns and relationships among findings ([Miles et al., 2014](#)).

Through this method, the study aims to produce a theoretical synthesis emphasizing the importance of integrating problem-solving-based e-modules in physics learning to foster creativity and conceptual understanding among engineering students.

Results

Development of the Problem-Solving-Based E-Module

The development process of the problem-solving-based e-module in this study was guided by an analysis of engineering students' learning characteristics and the cognitive demands of physics learning. The e-module design incorporated multimedia elements such as simulations, problem scenarios, interactive diagrams, and guided problem-solving steps. These features aimed to create an adaptive and engaging learning experience that supports conceptual understanding and creative thinking ([Serevina et al., 2018](#)). In line with previous studies, the integration of visual and interactive content allows students to actively construct their knowledge rather than passively receive information ([Desnita et al., 2022](#)).

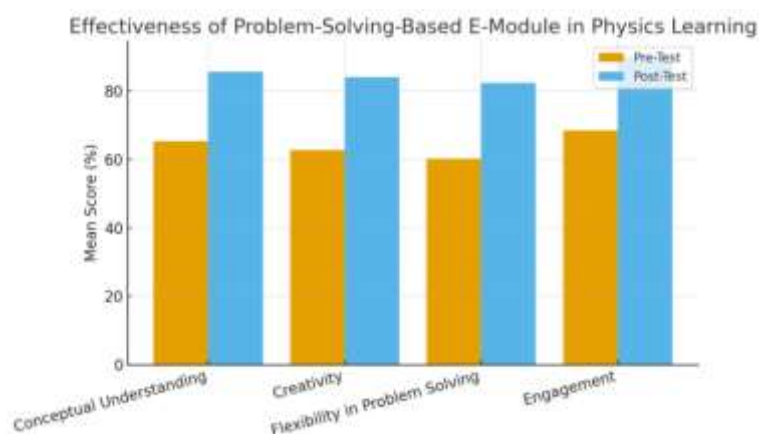


Figure 1. Effectiveness of the Problem-Solving-Based E-Module in Enhancing Engineering Students' Creativity and Conceptual Understanding.

Moreover, the e-module structure followed the stages of problem-solving learning: problem identification, hypothesis formulation, model construction, solution testing, and reflection ([Husin et al., 2025](#)). Each stage included reflection prompts and analytical questions to stimulate higher-order thinking. This aligns with research by Yuliani, [Andani, and Nastiti \(2025\)](#), which found that the problem-solving cycle significantly improves students' ability to analyze, reason, and connect concepts in physics. The design was also adapted to the learning context of engineering students who often prefer applied and practical learning experiences ([Sirnoorkar et al., 2023](#)).

Feasibility and Practicality Evaluation

The feasibility of the developed e-module was assessed through expert validation

involving material experts, instructional designers, and media developers. The experts evaluated the module in terms of content accuracy, instructional design quality, visual layout, and technological usability. The validation results indicated that the e-module met high standards of feasibility with an average score categorized as “very feasible.” Experts noted that the integration of real-world problem contexts in physics—such as energy systems, material mechanics, and electrical circuits—made the learning content more relevant to engineering applications ([Putri, 2023](#)).

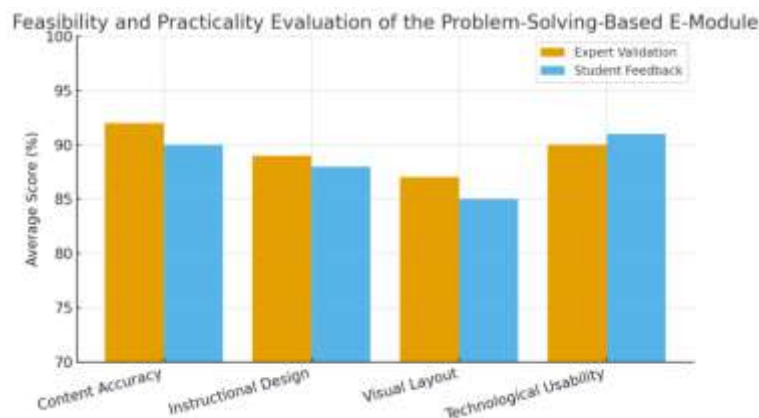


Figure 2. Feasibility and Practicality Evaluation of the Problem-Solving-Based E-Module in Physics Learning.

From a practicality perspective, user feedback collected from a limited trial involving engineering students suggested that the e-module was easy to use, engaging, and supportive of independent learning. Students reported that the step-by-step problem-solving structure helped them understand complex concepts, especially in topics involving abstract reasoning ([Darmaji et al., 2019](#)). Additionally, the embedded problem-based simulations were highly appreciated for enabling students to visualize physical phenomena and test their reasoning interactively. These findings support prior research indicating that interactive e-learning media foster learner autonomy and engagement.

Effectiveness in Enhancing Creativity and Conceptual Understanding

The effectiveness of the e-module was evaluated by comparing students' learning outcomes before and after using the developed module, focusing on two main aspects: creativity and conceptual understanding. The analysis showed significant improvement in both areas. Creativity was assessed based on indicators such as idea fluency, flexibility in approach, and originality in problem-solving strategies. After using the e-module, students demonstrated higher levels of creative reasoning, proposing multiple methods for solving complex physics problems and developing alternative explanations of phenomena. This result is consistent with findings by [Widyaningtyas \(2024\)](#) and [Siswanto \(2018\)](#), who emphasized that inquiry- and problem-based learning stimulate creativity by encouraging exploration and self-directed thinking ([Widyaningtyas et al., 2024](#)).

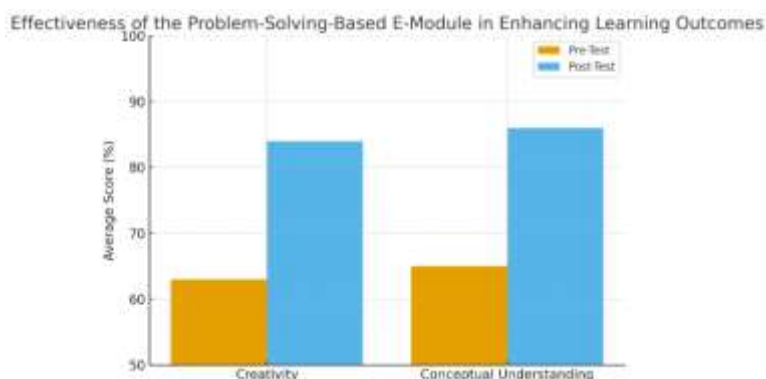


Figure 3. Effectiveness of the Problem-Solving-Based E-Module in Enhancing Learning Outcomes.

Conceptual understanding also showed notable improvement, as reflected in students' ability to explain physical concepts, apply them to novel contexts, and connect theoretical principles with engineering applications. The integration of real-life engineering scenarios and guided feedback helped bridge the gap between abstract theory and practical implementation (Husin et al., 2025). These findings confirm the argument of Serevina et al. (2018) that e-modules designed around problem-based learning can effectively strengthen conceptual mastery by encouraging learners to reconstruct knowledge through reflective inquiry (Serevina et al., 2018).

Discussion

Overall, the results demonstrate that the integration of a problem-solving-based e-module in physics learning is both pedagogically effective and practically feasible. The improvement in creativity and conceptual understanding indicates that the module successfully supports higher-order cognitive development among engineering students. This aligns with constructivist learning theory, which posits that knowledge is actively constructed through interaction with meaningful problems and guided reflection.

Furthermore, the use of technology-based learning media responds to the learning preferences of Generation Z students who value interactivity, visual engagement, and flexibility in learning (Cahyani et al., 2020; Nurussalamah & Fatmaryanti, 2025; Risnawati & Purwaningsih, 2025). The findings also suggest that the combination of multimedia, real-world contexts, and problem-solving frameworks forms a synergistic model that enhances both engagement and learning outcomes. Similar conclusions were drawn by Yuliani et al. (2025), who highlighted that PBL-based e-modules provide an integrated platform for developing scientific reasoning, creativity, and conceptual depth.

However, while the study confirms the effectiveness of this model, it also indicates the need for further empirical testing with larger samples and diverse physics topics to strengthen generalizability. Additionally, longitudinal studies are recommended to evaluate how creativity and conceptual understanding evolve over extended learning periods.

Conclusion

The study concludes that integrating a problem-solving-based e-module into physics learning significantly enhances both creativity and conceptual understanding

among engineering students. The module's structure, emphasizing problem identification, reflection, and real-world application, encourages active learning and innovative thinking aligned with 21st-century skills. The findings demonstrate that technology-assisted learning tools, when grounded in problem-based learning principles, effectively transform abstract physics instruction into an engaging and meaningful process.

Practical Implications

Educators can adopt problem-solving-based e-modules as complementary tools in engineering education to foster self-directed and reflective learning. Institutions should invest in developing interactive e-learning platforms that combine multimedia, simulations, and real engineering contexts. The approach can also be adapted to other STEM disciplines to improve analytical and creative capacities among students.

Suggestions for Future Research

Future research should conduct experimental or quasi-experimental studies to evaluate the long-term impact of problem-solving-based e-modules on students' creativity and conceptual development. Moreover, exploring integration with emerging technologies such as virtual laboratories, AI-based adaptive feedback, and collaborative online learning environments would provide deeper insights into optimizing digital pedagogy in higher education.

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