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Needs Analysis for the Development of a Contextual Physics Interactive E-Module Based on Deep Learning to Enhance Critical Thinking Skills

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Abstract: Physics learning at the senior high school (SMA/MA) level still faces challenges in developing students' critical thinking skills. This is largely due to the use of instructional materials that are less interactive and the limited implementation of contextual learning approaches. On the other hand, the rapid advancement of digital technology provides significant opportunities to create more engaging, flexible, and meaningful learning experiences through digital-based media. This study aims to analyze the need for developing a contextual physics interactive e-module based on a deep learning approach to enhance students' critical thinking skills. The research employs a Research and Development (R&D) method using the Plomp development model, which includes the preliminary research, prototyping phase, and assessment phase, with a focus on the need analysis stage. Data were collected through tests, questionnaires, interviews, and documentation studies related to the current learning conditions in schools. The results indicate that students prefer digital-based learning as it is more engaging, interactive, and accessible anytime and anywhere. Furthermore, schools have provided adequate supporting facilities such as technological devices and internet access. However, the use of digital teaching materials in physics learning is still not optimal and has not yet integrated contextual and deep learning approaches. Therefore, the development of an interactive e-module based on deep learning is highly needed as an innovative solution to improve students' critical thinking skills.

Keywords: Contextual; Critical thinking skills; Deep learning; Interactive e-modules; Physics

Introduction

Physics learning at the senior high school (SMA/MA) level is ideally directed toward developing higher-order thinking skills, particularly critical thinking, through deep and applicable conceptual understanding. Physics should not be viewed merely as a collection of formulas, but as a scientific way of thinking to explain natural phenomena. In the context of the Merdeka Curriculum, learning is expected to be student-centered, contextual in nature, and capable of integrating digital technology to create meaningful learning experiences (Haq & Wakidi, 2024; Mayasari et al., 2016). Thus, physics learning can connect abstract concepts with real-life situations.

In line with 21st-century developments, the use of digital technology has become essential in the learning process (Asrizal et al., 2018). Digital technology enables the presentation of materials in an interactive manner through various multimedia formats such as animations, videos, and simulations, which can enhance student engagement (Hidayati, 2025, Chisunum & Nwadiokwu, 2024). In addition, the use of digital teaching materials supports independent and flexible learning, allowing students to access content anytime and anywhere (Prameswaro et al., 2023). This indicates

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that the integration of digital technology in physics learning is inevitable. However, the actual conditions of physics learning in the field have not yet fully met these expectations.

Physics learning in schools still tends to be abstract and focuses primarily on solving mathematical problems without linking concepts to real-life phenomena. As a result, students experience difficulties in achieving deep conceptual understanding and tend to memorize without grasping the underlying meaning (Ubaidillah et al., 2025). This condition has an impact on the low level of students' critical thinking skills as well as the high occurrence of misconceptions in physics learning (Khairani & Rifai, 2025).

In addition, learning methods in schools are still dominated by conventional approaches such as lectures, textbooks, and simple presentations. These methods have not been able to accommodate the diverse learning needs of students, both in terms of learning styles and thinking abilities (Yang, 2024). On the other hand, although technological facilities such as digital devices and internet access are already available in many schools, their utilization in the learning process is still not optimal (Timotheou et al., 2023).

One approach that can be used to address these problems is contextual learning. This approach allows students to relate physics concepts to phenomena they encounter in everyday life, making learning more meaningful and easier to understand (Akhsan & Wiyono, 2025). Through contextual learning, abstract concepts can be explained through real experiences, thereby enhancing students' understanding as well as their critical thinking skills. Furthermore, to further optimize critical thinking abilities, a more in-depth learning approach is needed, one of which is the deep learning approach.

The deep learning approach in education emphasizes deep conceptual understanding, the interconnection between concepts, and the development of higher-order thinking skills. Learning based on deep learning encourages students not only to understand information at a surface level but also to analyze, evaluate, and apply knowledge in various contexts (Weng et al., 2023). Therefore, integrating this approach into physics learning is highly relevant for enhancing students' critical thinking skills.

The development of interactive e-modules is one solution that can integrate digital technology, contextual learning, and the deep learning approach. Interactive e-modules have the advantage of presenting material in an engaging and interactive way through a combination of text, images, audio, video, and simulation (Safitri & Dafit, 2025). In addition, e-modules allow for built-in evaluation features that help students assess their understanding independently. Thus, interactive e-modules can serve as effective instructional materials to improve the quality of physics learning (Hake, 1998).

Several previous studies have shown that the use of digital and interactive teaching materials can improve students' learning outcomes and critical thinking skills. Research by Rosbina et al. (2025) indicates that web-based interactive learning media can enhance students' learning independence. Wahidin et al. (2025) also state that digital teaching materials can help students understand abstract concepts more concretely. In addition, a study by Santoso et al. (2023) shows that contextual-based learning can increase the meaningfulness of learning and the connection between concepts and real-life situations. However, studies that integrate interactive e-modules, deep learning approaches, and contextual physics learning are still limited.

Based on the above discussion, there is a gap between the ideal conditions of physics learning and the reality in the field, particularly in terms of the use of interactive, contextual, and digital-based teaching materials. Therefore, a needs analysis is required as an initial step in developing instructional materials that align with students' characteristics and curriculum demands. This study aims to analyze the need for developing a contextual physics interactive e-module based on a deep learning approach to enhance the critical thinking skills of senior high school (SMA/MA) students (Haryati & Wangid, 2023).

Method

This study employs a Research and Development (R&D) method using the Plomp development model, which consists of three main phases: preliminary research, prototyping phase, and assessment phase (Plomp & Nieveen, 2013). However, this study focuses on the initial stage, namely the preliminary research phase, which aims to analyze the need for developing a contextual physics interactive e-module based on a deep learning approach.

The study was conducted at a senior high school in Padang City, with research subjects consisting of students and a physics teacher. The sampling technique used was purposive sampling, taking into account the representativeness of school characteristics and the availability of learning technology facilities.

At the preliminary research stage, the activities carried out include: (1) curriculum analysis to identify the alignment of physics content with the requirements of the Merdeka Curriculum, (2) analysis of student characteristics, including learning styles, interests, and critical thinking skills, (3) analysis of teaching material needs through questionnaires and interviews, and (4) analysis of learning conditions in schools, including the availability of technological facilities.

The research instruments used include a student needs analysis questionnaire, a teacher interview guide, and an observation sheet of learning conditions. The questionnaire was designed using a Likert scale to measure students' perceptions of the use of digital teaching materials in physics learning. The interviews were conducted in a semi-structured manner to obtain in-depth information regarding challenges and learning needs from the teacher's perspective.

The data analysis techniques used in this study were quantitative and qualitative descriptive analysis. Questionnaire data were analyzed using percentages to describe the tendencies of students' responses, while interview and observation data were analyzed qualitatively through data reduction, data display, and conclusion drawing. The results of this analysis were used as the basis for formulating the initial specifications for the development of a deep learning–based interactive e-module. The research flow can be seen in Figure 1.

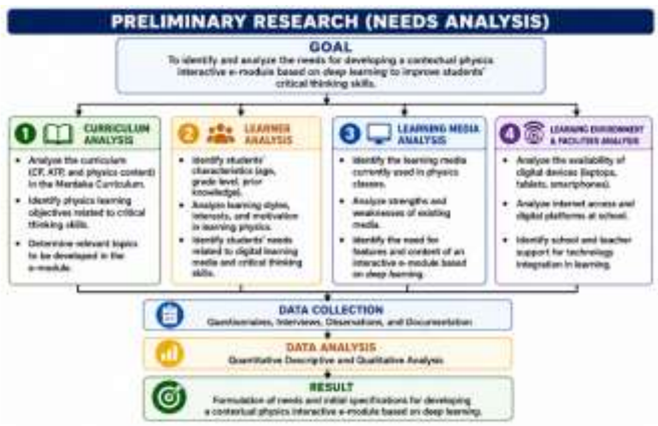

Figure 1. Research Flowchart

Result and Discussion

Based on the preliminary research stage, several key findings were obtained that serve as the foundation for developing a deep learning–based interactive e-module. The results of the study are presented based on four main aspects: curriculum analysis, student characteristics, the need for teaching materials, and the conditions of learning in schools (Kurniati et al., 2021).

Curriculum Analysis

The results of the curriculum analysis indicate that physics content in the Merdeka Curriculum emphasizes the development of critical thinking skills, problem-solving abilities, and the connection of concepts to real-life contexts. However, its implementation in practice tends to focus on the delivery of theoretical concepts and has not fully accommodated student-centered learning. This shows a gap between the curriculum demands and the actual teaching practices taking place in the classroom (Diarsa, 2021).

In addition, the implementation of the Merdeka Curriculum with a deep learning approach has not been optimally carried out in schools, resulting in students' critical thinking skills remaining relatively low. Although the Merdeka Curriculum explicitly emphasizes the development of higher-order thinking skills (HOTS), in practice, learning is still dominated by activities focused on mastering basic concepts and solving routine problems. Students tend to experience difficulties in analyzing problems, evaluating information, and expressing arguments logically and systematically. This indicates that the learning strategies implemented have not fully supported the achievement of curriculum demands in developing students' critical thinking skills optimally.

These findings are supported by the results of a critical thinking skills test conducted on the topic of temperature and heat in Grade XI (Phase F). The results indicate that students' critical thinking skills are still in the low category. The results of the critical thinking skills test are presented in Figure 2.

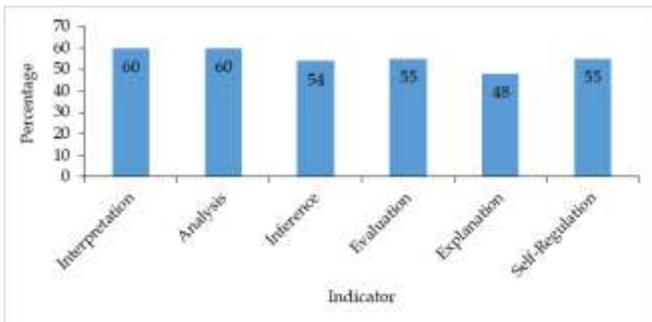

Figure 2. Percentage of students' critical thinking skills

The results of the analysis of students' critical thinking skills presented in Figure 2 indicate that all indicators are still in the moderate to low categories, particularly in the aspects of explanation, inference, and evaluation. These findings suggest that students' higher-order thinking skills have not yet developed optimally. This condition is not in line with the demands of the Merdeka Curriculum, which emphasizes the development of 21st-century competencies, especially critical thinking skills as part of higher-order thinking skills (HOTS). Within the Merdeka Curriculum, learning is designed to encourage students to actively construct knowledge through analytical, reflective, and contextual thinking processes (kemendikbudristek, 2022). Furthermore, the Pancasila Student Profile highlights the importance of critical reasoning, which includes the ability to obtain and process information, analyze, evaluate, and reflect on one's thinking independently. However, based on the findings of this study, these indicators have not been optimally achieved, particularly in the abilities of explanation and inference, which are essential components of critical reasoning.

The low achievement in the explanation indicator (48%) indicates that students are not yet able to communicate their ideas systematically. This condition contradicts the principles of learning in the Merdeka Curriculum, which emphasize the importance of scientific communication in the learning process. Similarly, the relatively low scores in the evaluation and inference indicators show that students are not yet accustomed to critically evaluating information and drawing evidence-based conclusions, which are core components of higher-order thinking skills (HOTS) (Anderson & Krathwohl, 2001).

Thus, these findings reveal a gap between curriculum expectations and actual conditions in the field. Therefore, innovation in learning is needed to bridge this gap. One possible alternative is the implementation of the Merdeka Curriculum through a deep learning approach, which is designed to train students to analyze, evaluate, and construct knowledge in a more in-depth manner.

Analysis of Student Characteristics

The analysis of student characteristics shows that most students tend to have an audiovisual learning style. This finding was obtained through school observations and the distribution of questionnaires related to students' learning styles. The results can be seen in Figure 3.

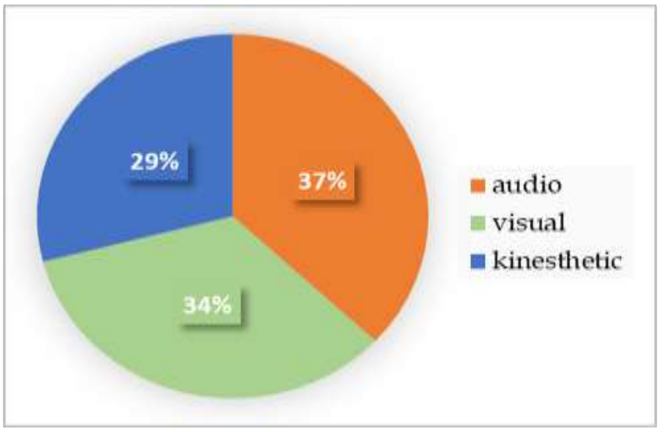

Figure 3. Results of learning style analysis of students

The pie chart (Figure 3) shows the distribution of students' learning styles, consisting of auditory (37%), visual (34%), and kinesthetic (29%). This data indicates that most students tend to prefer learning through listening, such as teacher explanations, discussions, or audio-based media (Herlina et al., 2020). However, the differences among the three learning styles are not very significant, suggesting that students' learning characteristics are relatively diverse and not dominated by a single style. Students with visual learning preferences are nearly equal in number to those with auditory preferences, meaning they better understand material through images, graphs, diagrams, or concept visualizations. Meanwhile, a considerable proportion of students exhibit kinesthetic learning preferences, highlighting the importance of hands-on activities, experiments, and direct experiences in the learning process.

The implication for learning, particularly in physics education, is the need to implement a multimodal approach that integrates verbal explanations, concept visualization, and experimental or hands-on activities. This approach has been shown to enhance students' conceptual understanding and engagement in the learning process (Gebremeskel et al., 2025). In addition, effective learning should consider the interconnection between cognitive, social, and emotional aspects to create meaningful learning experiences (Kuo et al., 2024). More broadly, the use of flexible and student-centered learning strategies aligns with recommendations from modern educational research, which emphasize the importance of interactive and multimodal learning environments (Kerimbayev et al., 2023; Jonassen, 2016). Therefore, integrating various learning styles into a single instructional design becomes a key factor in improving the quality of learning and students' learning outcomes.

Furthermore, students also show a relatively high level of interest in the use of digital materials in learning. The results of the questionnaire regarding students' needs can be seen in Figure 4.

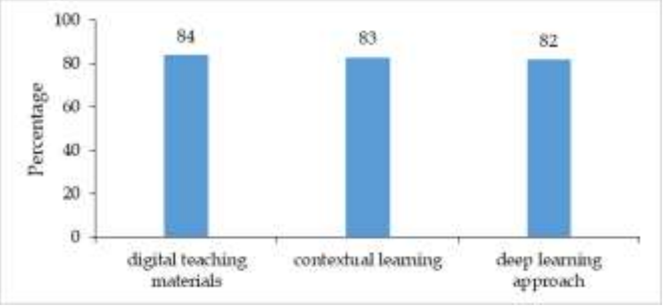

Figure 4. Student needs analysis

Figure 4 it shows the results of a needs analysis on three main aspects of learning: digital teaching materials (84%), contextual learning (83%), and the deep learning approach (82%). The high percentages across these three aspects indicate that students strongly need learning that integrates digital technology, real-life contexts, and deep understanding. This condition provides a strong foundation for the development of deep learning–based e-modules, as e-modules as digital instructional materials are capable of accommodating these needs in a systematic and structured manner.

In the context of e-module development, the high demand for digital teaching materials (84%) indicates that e-modules are a relevant solution, as they can present content interactively through a combination of text, images, animations, and videos. This allows students to learn independently and flexibly in accordance with the characteristics of 21st-century learning. Furthermore, the need for contextual learning (83%) can be integrated into e-modules through the presentation of real-world problems, everyday phenomena, or case studies related to physics concepts, thereby helping students connect theory with practical applications. Meanwhile, the deep learning approach (82%) becomes the core of e-module development, involving the design of activities that encourage analysis, evaluation, and problem-solving, rather than merely surface-level understanding of concepts.

Thus, the development of deep learning–based e-modules should be designed not only as instructional materials that deliver information, but also as tools to build deep conceptual understanding through meaningful learning activities. This is supported by research indicating that the use of multimedia in digital teaching materials can enhance conceptual understanding and student engagement (Chisunum & Nwadiokwu, 2024). In addition, the integration of real-life contexts in learning has been shown to improve the relevance and retention of learning materials (Tutal, 2023). Furthermore, the deep learning approach in instructional design encourages students to develop critical thinking and problem-solving skills optimally (Ayatin et al., 2024). Therefore, the results of this needs analysis reinforce the urgency of developing deep learning–based e-modules as an effective, contextual, and innovative learning solution aligned with the demands of modern education.

Teacher Interview

Based on the results of interviews with the physics teacher, it was found that physics learning at the school has adopted the Merdeka Curriculum, although its implementation has not yet been fully optimal. The teacher stated that one of the main challenges faced is the difficulty in designing and aligning the learning flow within teaching modules to match the characteristics of the Merdeka Curriculum. In addition, although digital devices have been utilized in classroom practice, their use is still limited and not yet fully integrated to support students' conceptual understanding (Nilyani et al., 2023). The learning models most frequently used are Problem-Based Learning (PBL) and discovery learning, which are generally aligned with active learning approaches; however, in practice, they still encounter challenges in promoting full student engagement.

Furthermore, the interview results reveal that the teaching materials used are still dominated by PowerPoint and simple modules, while the use of e-modules has not yet been maximized. The teacher stated that the main challenges in developing and using e-modules are limited technical skills and a lack of experience in designing interactive digital teaching materials (Krisnayuni et al., 2017). As a result, the learning process has not fully supported students in achieving deep understanding, particularly in topics such as temperature and heat, which require visualization and contextual experiences. On the other hand, the teacher emphasized that the development of e-modules is highly necessary, as they can support independent learning, facilitate easier concept understanding, and increase students' interest through more interactive presentation.

The teacher also emphasized that an ideal e-module should be equipped with various features such as instructional videos, animations, simulations, and interactive quizzes to support independent learning and increase student engagement. In addition, the development of context-based e-modules, such as those integrating biophysics and a deep learning approach, is considered essential, as it can make learning more meaningful and help students understand the connection between physics concepts and everyday life (Fidan & Tuncel, 2019).

These findings are consistent with recent studies indicating that multimedia-based digital teaching materials can significantly improve students' conceptual understanding and engagement (Kusmayadi et al., 2026). Furthermore, contextual learning has been proven effective in helping students relate concepts to real-life experiences, thereby enhancing learning retention (Sari et al., 2024). The deep learning approach is also supported by research showing that learning activities emphasizing analysis, reflection, and problem-solving can improve higher-order thinking skills (Yadav, 2026). Therefore, these interview results reinforce the urgency of developing deep learning–based e-modules as an innovative solution to address various challenges in physics learning and to support the more effective implementation of the Merdeka Curriculum (Festiyed et al., 2022).

Based on the results of the student needs analysis and teacher interviews, the main problems in physics learning lie in the suboptimal use of digital teaching materials, the lack of connection between content and real-life contexts, and the absence of learning that facilitates deep understanding. Therefore, it is necessary to develop a contextual physics interactive e-module based on a deep learning approach that integrates technology, real-life contexts, and higher-order thinking activities. This e-module should include interactive features such as videos, animations, simulations, and digital quizzes to enhance student engagement and support independent learning. In addition, presenting materials based on real-life contexts is essential to make physics concepts more meaningful and easier to understand (Kemendikbud, 2022).

The deep learning approach in the e-module is implemented through activities involving analysis, problem-solving, and reflection, which encourage students to construct deep conceptual understanding. This is in line with studies indicating that the integration of digital technology in learning can improve the quality of interaction and student learning outcomes (Alfaruque et al., 2023), and that context-based interactive teaching materials are effective in enhancing conceptual understanding and learning motivation (Yılmaz et al., 2022). Furthermore, the deep learning approach significantly contributes to the development of critical thinking and problem-solving skills (Sudarmono et al., 2025). Therefore, the development of interactive e-modules based on deep learning is a strategic solution to improve the effectiveness of physics learning in accordance with the demands of the Merdeka Curriculum and 21st-century education.

Conclusion

Based on the results of the needs analysis of students and teacher interviews, it can be concluded that physics learning still faces challenges in optimizing the use of digital teaching materials, linking content to real-life contexts, and developing students' deep understanding. Although students have diverse learning styles (auditory, visual, and kinesthetic) and the implementation of the Merdeka Curriculum has begun, learning practices are still dominated by conventional methods with limited use of technology. Therefore, the development of a contextual physics interactive e-module based on a deep learning approach is a relevant and strategic solution, as it integrates interactive multimedia, real-life contexts, and learning activities that promote critical, analytical, and reflective thinking. Thus, this e-module not only supports more engaging and flexible learning but also enhances students' conceptual understanding and higher-order thinking skills in line with the demands of the Merdeka Curriculum and 21st-century learning.

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Author Contributions
Etri Alga Vrimesty, as the main author, was responsible for conceptualizing the study, collecting and analyzing data, and writing the manuscript. Ratnawulan served as the supervisor, conducting review, validation, and ensuring the accuracy of the content. Ahmad Fauzi contributed by reviewing and improving the writing of the article. Meanwhile, Emiliannur was responsible for enhancing the quality of the writing and refining the references used in this article.

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Conflicts of Interest
The author declares that he/she has no conflict of interest.

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