Journal of Innovative Physics Teaching
Volume 4, Issue 2 Desember 2026, 231- 243
ISSN: 3021-8551 (Online)
Doi: https://doi.org/10.24036/jipt/vol4-iss2/160
https://jipt.ppj.unp.ac.id/index.php/jipt

Needs Analysis of E-Module for Linear Motion Integrated with Problem Based Learning and Education for Sustainable Development to Facilitate Critical Thinking Skills

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Article Info

Article history:

Received June 27, 2026
Revised July 19, 2026
Accepted July 27, 2026

Keywords:

Critical Thinking
E-Module
Education for Sustainable Development
Linear Motion
Problem-Based Learning

ABSTRACT

The rapid advancement of digital technology and the demands of twenty-first-century education require instructional materials that foster students' critical thinking skills and sustainability competencies. However, physics learning on the topic of linear motion is still dominated by conventional teaching materials that provide limited opportunities for contextual problem-solving and meaningful learning experiences. Therefore, this study aimed to identify instructional needs as a basis for developing a Canva Site-based e-module integrating Problem-Based Learning (PBL) and Education for Sustainable Development (ESD) to facilitate senior high school students' critical thinking skills. This study employed a Research and Development (R&D) method using the 4D development model, limited to the Define stage. Data were collected through critical thinking tests, student questionnaires, and teacher interviews involving 34 eleventh-grade students and one physics teacher at SMAN 9 Padang. The findings showed that students' critical thinking skills were relatively low, with an average score of 37.12%, while the interpretation indicator obtained the lowest percentage (29.4%). In addition, 86% of students expressed interest in digital learning materials. These findings indicate a need for the proposed e-module to support interactive, meaningful, and sustainability-oriented physics learning, providing a foundation for developing innovative digital learning resources that enhance students' critical thinking skills.

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INTRODUCTION

The rapid advancement of digital technology has transformed various aspects of education, including the learning process. Technology integration creates more dynamic, flexible, and student-centered learning environments. Technology enhances access to

learning resources while supporting the development of critical thinking and problem-solving skills (Haleem et al., 2022). Recent studies suggest that digital technology supports interactive and accessible physics learning by visualizing abstract concepts and enhancing students' digital literacy (Astuti et al., 2024). In response to these demands, twenty-first-century education no longer focuses solely on knowledge acquisition but also emphasizes the development of the 4C competencies, namely critical thinking, creativity, collaboration, and communication, which enable students to respond effectively to complex global and sustainability challenges (Taufiqurrahman, 2023). Therefore, transforming educational approaches has become imperative to prepare future generations capable of addressing global challenges while contributing to sustainable development, one of which can be achieved through the implementation of Education for Sustainable Development.

Education for Sustainable Development integrates sustainability principles into teaching and learning to develop learners' knowledge, skills, values, and competencies that enable them to make responsible decisions and contribute to sustainable development Azmi et al., 2024). ESD not only emphasizes knowledge acquisition but also fosters learners' understanding of the interconnections among environmental, social, and economic dimensions, enabling them to become active agents of change in society (Kioupi & Voulvoulis, 2019). Through transformative and student-centered learning experiences, ESD promotes critical thinking, problem-solving, creativity, and responsible decision-making, enabling learners to address complex sustainability challenges (Ubaidillah et al., 2023). Therefore, ESD represents a relevant approach for developing the competencies required for twenty-first-century life.

Among the various competencies required in the twenty-first century, critical thinking is considered one of the most essential skills that should be fostered through education. According to Facione (2020), critical thinking is a purposeful and self-regulatory process of judgment that involves six core cognitive skills: interpretation, analysis, evaluation, inference, explanation, and self-regulation. These skills enable learners to interpret information, evaluate evidence objectively, draw reasonable conclusions, connect concepts meaningfully, and solve problems based on logical reasoning, making critical thinking an essential competency for science learning (Nainggolan et al., 2023). Therefore, developing students' critical thinking skills has become one of the primary objectives of physics education to prepare learners for addressing complex scientific and real-world problems.

In physics education, critical thinking plays a particularly important role because students are required to understand concepts comprehensively, analyze natural phenomena, and solve scientific problems systematically. One effective way to develop this ability is by connecting physics concepts with real-world phenomena. Through contextual learning, students can better understand concepts, analyze problems, and apply their knowledge to make reasoned decisions (Susilawati et al., 2020). Furthermore, learning activities that are closely related to students' experiences and surrounding environments encourage deeper analysis of the phenomena being studied (Kurniawan & Syafriani, 2021). Students with strong critical thinking skills are more likely to minimize misconceptions, solve problems through conceptual reasoning, and evaluate physical phenomena scientifically (Amalia & Kustijono, 2017). Despite its recognized importance, fostering critical thinking effectively in physics classrooms remains a significant educational challenge.

Physics learning in schools still faces various challenges in facilitating conceptual understanding and developing students' higher-order thinking skills. Learning activities often emphasize content delivery and mathematical problem-solving, leading students to rely more on formula memorization than on meaningful conceptual understanding. Previous studies have reported that students' abilities to analyze problems, evaluate information, construct scientific arguments, relate concepts to everyday phenomena, and draw conclusions

based on evidence remain relatively low (Ardiyanti & Nuroso, 2021; Sulbiana et al., 2024). These findings indicate that improving physics instruction requires learning approaches that engage students in inquiry, contextual problem-solving, and critical reasoning.

Similar findings emerged from a preliminary needs analysis conducted at a senior high school through critical thinking tests, student questionnaires, teacher interviews, and teaching material analysis. The analysis revealed that students demonstrated limited critical thinking abilities, low reading interest, and a strong dependence on textbook-based learning resources. One contributing factor is the limited availability of teaching materials that effectively facilitate active student engagement and support the development of critical thinking skills (Hadad et al., 2025). Low levels of critical thinking were also identified in the topic of linear motion, as indicated by the small number of students who achieved the Learning Objective Achievement Criteria for this topic (Nisa & Dewi, 2025). These findings are consistent with those of Afifah et al. (2025), who reported that the physics learning materials currently used in schools do not adequately embed innovative instructional approaches, resulting in students' low critical thinking skills and highlighting the need for contextual, technology-assisted teaching resources. Furthermore, Rahmayani & Asrizal (2023) reported that the utilization of information and communication technology (ICT) in physics learning has not been fully optimized despite the considerable technological potential available in schools, emphasizing the need to develop innovative technology-based e-modules to better support students' learning.

Linear motion is one of the fundamental topics in physics and serves as the foundation for understanding more advanced concepts in mechanics (Erwinsyah et al., 2020). However, classroom evidence indicates that this topic is among the most difficult for students to understand. These difficulties arise because learning linear motion requires conceptual understanding, mathematical competence, and the ability to interpret multiple representations, such as motion graphs and equations, simultaneously. As a result, students often experience misconceptions related to distance, displacement, velocity, and acceleration (Ady & Warliani, 2022). In addition to being a fundamental physics concept, linear motion is closely related to everyday phenomena, such as transportation and human mobility, making it a potential context for implementing ESD-oriented learning.

To address these challenges, innovative teaching materials that promote independent learning and strengthen students' critical thinking skills are needed, with electronic modules (e-modules) representing a promising alternative. E-modules provide students with opportunities for independent learning through interactive, systematic, and easily accessible instructional materials (Herawati & Muhtadi, 2018). A recent meta-analysis revealed that implementing e-modules can substantially improve students' critical and creative thinking skills in science learning by promoting active and independent knowledge construction (Asrizal et al., 2023). Furthermore, integrating e-modules with Problem-Based Learning (PBL) provides an effective learning environment because students are engaged in contextual problem-solving activities that encourage analysis, evaluation, and independent knowledge construction (Novianti et al., 2025; Rasyid & Wiyatmo, 2024). However, previous studies have reported that ESD has not yet been explicitly integrated into electronic learning media, despite teachers recognizing its importance for supporting meaningful and sustainability-oriented learning (Salam et al., 2022). Therefore, integrating ESD into physics e-modules represents an important step toward developing learning resources that foster both critical thinking and sustainability competencies.

To maximize the potential of e-modules in fostering critical thinking skills, an appropriate learning model should be integrated, namely Problem-Based Learning (PBL). PBL is a student-centered learning approach that encourages learners to investigate authentic problems, analyze information, develop solutions, and construct knowledge through

collaborative problem-solving activities, and has been widely recognized as one of the most effective instructional models for developing students' critical thinking skills (Hanifah et al., 2025). This finding is further supported by a recent systematic review and meta-analysis conducted by Su et al. (2025), which demonstrated that students who learned through PBL achieved significantly higher critical thinking skills than those who experienced conventional instruction. Furthermore, interactive physics e-modules based on PBL implemented in a blended-PBL learning environment have been shown to significantly improve senior high school students' critical thinking skills (Wardani et al., 2025). A systematic literature review revealed that PBL consistently contributes to the improvement of higher-order thinking skills in physics education by engaging students in problem-solving activities and promoting deeper conceptual understanding (Halim, 2025). However, to make learning more relevant to real-world challenges, PBL should incorporate sustainability issues into its problems.

Previous studies have mainly focused on the implementation of Problem-Based Learning or the development of digital learning materials to improve students' critical thinking skills. Despite the growing use of Problem-Based Learning in e-module development, its combination with Education for Sustainable Development remains insufficiently explored, especially in physics education. Moreover, studies that develop linear motion e-modules by integrating both PBL and ESD are still scarce. This condition indicates an opportunity to develop an integrated e-module that can simultaneously promote students' critical thinking skills and sustainability competencies within physics learning.

This study presents a needs analysis for the development of a linear motion e-module integrating Problem-Based Learning and Education for Sustainable Development to facilitate senior high school students' critical thinking skills. This study aims to identify the needs and characteristics of such an e-module in physics learning. The findings are expected to provide empirical evidence for designing innovative physics teaching materials that integrate PBL and ESD while supporting students' critical thinking skills and sustainability competencies. Ultimately, the results are intended to serve as a foundation for the subsequent design and development of the proposed e-module.

METHODS

This research adopted a Research and Development (R&D) approach based on the Four-D (4D) model introduced by Thiagarajan et al. (1974). The Four-D model comprises four sequential phases, namely Define, Design, Develop, and Disseminate, and provides a systematic framework for developing educational products. However, this study focused only on the Define phase, which was conducted to identify the preliminary needs serving as the basis for designing a physics e-module integrating Problem-Based Learning (PBL) and Education for Sustainable Development.

During the Define phase, the front-end analysis was conducted to identify learning problems and determine the need for innovative instructional materials. Learner analysis was then performed to examine students' characteristics, followed by concept analysis, task analysis, and the formulation of instructional objectives (Thiagarajan et al., 1974). In this study, the front-end analysis was conducted to identify problems in physics learning and the need for developing innovative instructional materials. Furthermore, the concept analysis and task analysis were conducted to determine the essential concepts, competencies, and learning tasks related to the topic of linear motion. Based on the results of these analyses, the instructional objectives were formulated as the foundation for developing the e-module in the subsequent stages.

The study was conducted at SMA Negeri 9 Padang during the second semester of the 2025/2026 academic year. The participants included one physics teacher and 34 eleventh-

grade students who had completed the linear motion topic in Phase E of the Independent Curriculum. Purposive sampling was employed to select participants who met the research criteria and provide relevant information regarding students' critical thinking skills, learning characteristics, and instructional material needs. The selected participants were considered appropriate because they had prior learning experience with the linear motion topic and were able to provide valid feedback on the existing instructional materials. These data formed the basis for identifying the requirements for developing the proposed physics e-module.

During the Define stage, data were gathered using three research instruments: a critical thinking skills test, a student needs analysis questionnaire, and a semi-structured interview protocol administered to the physics teacher. The critical thinking skills test consisted of six essay questions developed based on Facione (2020) critical thinking framework, covering six indicators of critical thinking: interpretation, analysis, evaluation, inference, explanation, and self-regulation. The student questionnaire was designed to identify students' learning characteristics, interest in digital learning materials, and readiness to use technology-based instructional media. Meanwhile, the semi-structured interview was conducted to obtain information regarding classroom learning conditions, students' learning difficulties, the instructional materials currently used, and the need for developing an e-module integrating Problem-Based Learning (PBL) and Education for Sustainable Development.

The collected data were analyzed descriptively according to the objectives of each analysis in the Define stage. Students' critical thinking skills test scores were converted into percentages for each indicator to describe their initial critical thinking profiles. Questionnaire responses were analyzed using descriptive percentages to identify students' learning characteristics and their need for digital instructional materials. The interview data were analyzed qualitatively through data reduction, data display, and conclusion drawing to identify learning problems and instructional needs that served as the basis for developing the proposed e-module. The findings from the front-end, learner, concept, task, and instructional objectives analyses were interpreted comprehensively to identify the gaps between existing instructional practices and the expected learning outcomes. The results of each analysis were then synthesized to formulate the design requirements and key features of the proposed Canva Site-based e-module integrating Problem-Based Learning (PBL) and Education for Sustainable Development (ESD). This analytical process ensured that the proposed instructional material was developed based on empirical evidence and aligned with students' learning needs, curriculum requirements, and sustainability-oriented learning objectives.

RESULTS AND DISCUSSION

Results

Front-End Analysis

The front-end analysis included an evaluation of the implementation of the Problem-Based Learning (PBL) model in physics instruction at SMAN 9 Padang. The analysis was conducted through a semi-structured interview with the physics teacher and focused on the implementation of each PBL syntax, including Problem Orientation (POR), Organizing Students for Learning (OSL), Guiding Investigation (GIN), Developing and Presenting the Work (DPW), and Analyzing and Evaluating the Problem-Solving Process (AEP). The purpose of this analysis was to identify strengths and areas for improvement in the current learning process as a basis for developing a linear motion e-module integrated with Problem-Based Learning (PBL) and Education for Sustainable Development. The results of the analysis are presented in Figure 1.

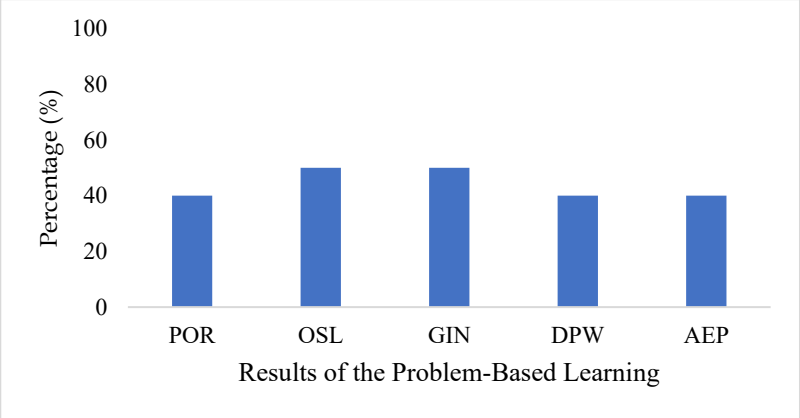

Figure 1. Results of the PBL Model Analysis

As illustrated in Figure 1, the implementation of PBL has not been consistently carried out across all learning stages. The OLS and GIN phases achieved the highest implementation level, with each reaching 50%, indicating that collaborative learning and investigation activities have been implemented to some extent. In contrast, the POR, DPW, and AEP phases each reached only 40%, suggesting that contextual problem orientation, student presentations, and reflective evaluation remain limited. These findings indicate that the current implementation of PBL has not yet fully supported inquiry-based learning or the development of students' critical thinking skills. Therefore, a Canva Site-based e-module integrating PBL and ESD is needed to strengthen each PBL phase through contextual learning activities, structured investigations, collaborative tasks, and reflective exercises.

Learner Analysis

This study analyzed students' critical thinking skills using a test consisting of six essay questions developed based on Facione (2020) critical thinking framework. The test was administered to 34 eleventh-grade students who had completed the linear motion topic during Phase E of the Independent Curriculum at SMAN 9 Padang. The instrument assessed six indicators of critical thinking skills: interpretation (INT), analysis (ANL), evaluation (EXP), inference (INF), explanation (EVA), and self-regulation (SRG). The results for each indicator are presented in Figure 2, demonstrating that students' critical thinking skills across all measured indicators had not yet reached the expected level.

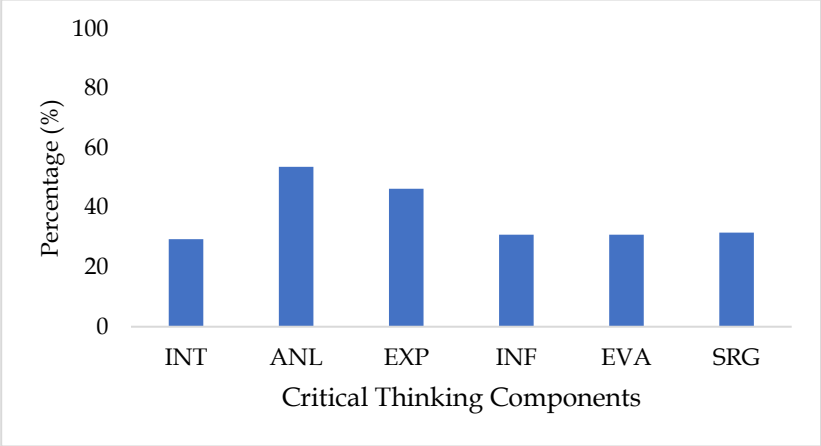

Figure 2. Results of Students' Critical Thinking Skills Test

The findings revealed that students' critical thinking skills remained below the expected level across all indicators, with an average achievement of 37.12%. The analysis indicator

obtained the highest percentage (53.7%), followed by explanation (46.3%), self-regulation (31.6%), evaluation (30.9%), inference (30.8%), and interpretation (29.4%), which recorded the lowest percentage. Although the analysis indicator achieved the highest score, it was the only indicator exceeding 50%, while the remaining five indicators were still below the expected average. These findings indicate that students' critical thinking skills were generally low and had not yet developed optimally across all dimensions. Therefore, improving each critical thinking indicator should become a major focus of the learning process, particularly through instructional materials that encourage students to observe, investigate, analyze, and draw conclusions independently.

The low performance in the interpretation indicator suggests that students still experience difficulties in understanding and identifying information presented in physics problems. Likewise, the low scores for the inference and evaluation indicators indicate that students are not yet able to draw evidence-based conclusions or provide logical justifications for their answers. An analysis of students' responses further revealed that most students tended to provide only the final answer without explaining the reasoning process used to reach it. Although the analysis indicator obtained the highest percentage, this ability was not supported by adequate interpretation and evaluation skills, resulting in students' critical thinking skills not being fully developed.

The questionnaire results also examined students' interest in digital learning based on their learning style characteristics. The findings indicated that students at SMAN 9 Padang predominantly exhibited an audiovisual learning style. Students with this learning style tend to learn more effectively through a combination of visual and auditory information. Therefore, designing an interactive physics e-module may better address students' learning preferences while creating a more engaging and effective learning experience.

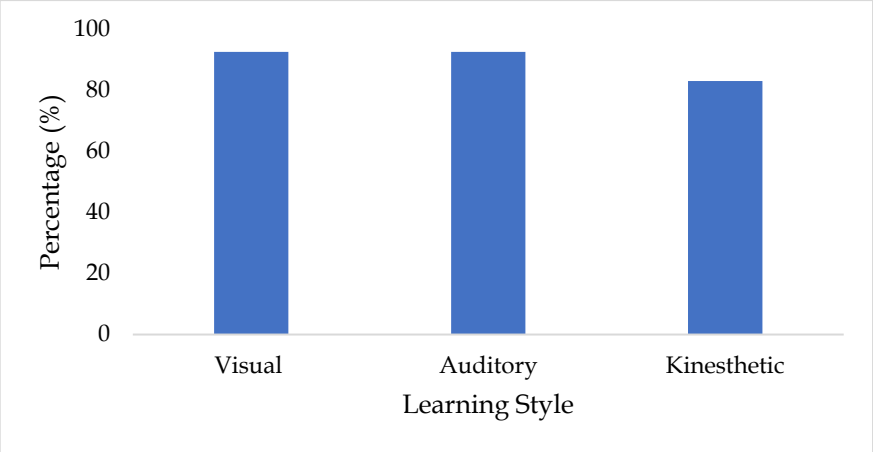

Figure 3. Graph of Student Learning Style Tendencies

As shown in Figure 3, students demonstrated a clear tendency toward an audiovisual learning style. This finding indicates that they understand learning materials more effectively when instruction combines visual and auditory elements, such as teacher explanations accompanied by images, graphs, illustrations, discussions, and instructional videos. The results also suggest that students have positive attitudes toward the integration of technology into the learning process, as technology-based learning media can present information in a more engaging, interactive, and comprehensible manner.

These findings are likely associated with learning practices that still emphasize concept delivery and procedural problem-solving. According to the teacher interview, students are rarely engaged in activities that develop their ability to interpret information, analyze contextual problems, and construct evidence-based arguments. Therefore, there is a need to

develop an ESD-integrated Problem-Based Learning (PBL) e-module that facilitates students in conducting investigations, analyzing information, drawing conclusions, and relating linear motion concepts to sustainability issues, thereby enhancing their critical thinking skills.

Task Analysis

The task analysis was conducted to evaluate the characteristics of the learning tasks assigned by the teacher in teaching linear motion. The analysis focused on six aspects, namely task alignment with the learning objectives, contextual tasks, critical thinking, investigation, collaboration and communication, and the integration of Education for Sustainable Development. The results of the task analysis are presented in Figure 4.

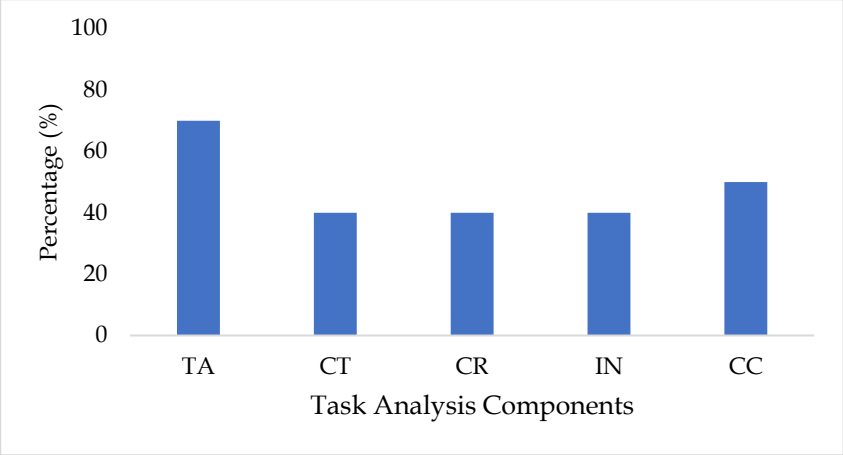

Figure 4. Results of Task Analysis

As illustrated in Figure 4, Task Alignment (TA) obtained the highest score (70%), indicating that the learning tasks are generally aligned with the learning objectives and the linear motion content. However, the Contextual Tasks (CT), Critical Thinking (CRT), and Investigation (INV) aspects each received only 40%, suggesting that the tasks provide limited opportunities for students to engage with authentic problems, analyze information, and conduct inquiry-based activities. The Collaboration and Communication (CC) aspect achieved a moderate score of 50%, indicating that although group discussions have been implemented, opportunities for students to communicate scientific ideas and present investigation results remain limited. These findings suggest that the current learning tasks are still dominated by routine exercises and have not fully supported the implementation of Problem-Based Learning (PBL) or the development of students' critical thinking skills. Therefore, a Canva Site-based e-module integrating PBL and Education for Sustainable Development (ESD) is needed to provide more contextual, collaborative, and inquiry-oriented learning tasks that foster students' critical thinking skills.

Concept Analysis

The concept analysis was conducted to evaluate the completeness and contextual presentation of the Linear Motion concepts currently used in physics learning at SMAN 9 Padang. The analysis covered ten key concepts, namely Motion (MOT), Linear Motion (LMO), Velocity (VEL), Acceleration (ACC), Distance (DST), Speed (SPD), Displacement (DSP), Uniform Linear Motion (ULM), Uniformly Accelerated Linear Motion (UAM), and Vertical Motion (VMT). Each concept was analyzed by comparing the expected condition with the actual condition of the existing teaching materials. The results of the concept analysis are presented in Figure 5.

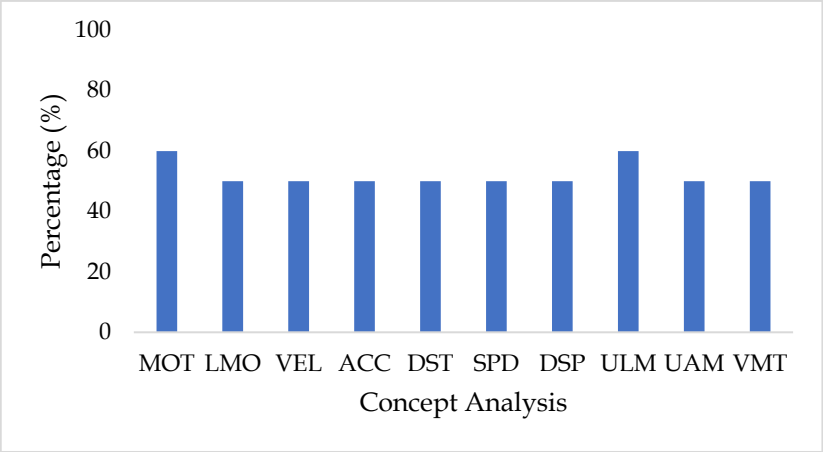

Figure 5. Results of the Concept Analysis

The results presented in Figure 5 indicate that the existing teaching materials provide a relatively better introduction to the concept of motion, which obtained the highest rating of 60%, while all other concepts received a score of 50%. This finding suggests that the learning materials have introduced the essential concepts of linear motion; however, the presentation remains largely focused on definitions and mathematical calculations, with limited contextual examples, inquiry-based activities, and opportunities for conceptual analysis. Consequently, students may encounter difficulties in relating physics concepts to real-life situations and developing critical thinking skills. Therefore, the development of a Canva Site-based e-module integrating Problem-Based Learning (PBL) and Education for Sustainable Development (ESD) is expected to provide more contextual learning experiences and strengthen students' conceptual understanding of linear motion.

Analysis of Learning Objectives

The instructional objectives analysis was conducted to evaluate the quality of the learning objectives for the topic of linear motion using the ABCD framework, which includes four components: Audience (AUD), Behavior (BEH), Condition (CON), and Degree (DEG). The analysis focused on determining whether the learning objectives clearly identified the intended learners, employed appropriate action verbs, specified the learning conditions, and defined measurable performance criteria. This analysis was carried out to ensure that the learning objectives support the implementation of Problem-Based Learning (PBL) and facilitate the development of students' critical thinking skills. The results of the instructional objectives analysis are presented in Figure 6.

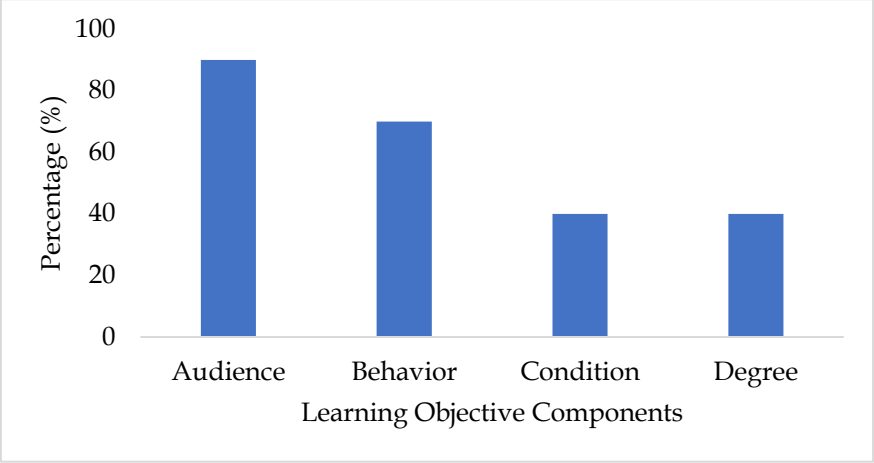

Figure 6. Results of the Instructional Objectives Analysis

As illustrated in Figure 6, the audience component obtained the highest rating (90%), indicating that the learning objectives consistently identify students as the intended learners. The behavior component achieved a rating of 70%, suggesting that most learning objectives use appropriate action verbs aligned with the expected competencies, although some objectives still require refinement to better reflect the intended cognitive level. In contrast, the condition and degree components received lower ratings of 40% and 50%, respectively, indicating that the learning objectives do not clearly specify the learning conditions or measurable performance criteria; therefore, improvements are still needed to provide clearer learning conditions and observable achievement criteria. Therefore, the developed Canva Site-based e-module was designed with learning objectives that fully incorporate the ABCD model to support the implementation of Problem-Based Learning (PBL) and facilitate the development of students' critical thinking skills.

Discussion

The front-end analysis revealed that although the school was equipped with adequate digital learning facilities, their utilization in physics instruction had not yet been optimized. The instructional materials were still predominantly textbook-based and lacked interactive features, contextual learning activities, and systematic integration of Education for Sustainable Development (ESD). These findings suggest that the availability of digital infrastructure alone is insufficient to support meaningful learning unless it is accompanied by appropriate instructional materials. This finding aligns with the conclusions of Haleem et al. (2022), who emphasized that the educational benefits of digital technology depend on its pedagogical integration rather than merely on the availability of technological resources. Likewise, Herawati & Muhtadi (2018) reported that interactive e-modules can enhance students' independent learning by providing structured and engaging learning experiences.

The learner analysis further revealed that students' critical thinking skills were generally low across all six indicators, particularly interpretation, inference, and evaluation. These findings are in line with Susilawati et al. (2020) and Nainggolan et al. (2023), who reported that senior high school students often experience difficulties in interpreting scientific information, evaluating evidence, and constructing logical arguments in physics learning. In addition, the questionnaire results showed that most students preferred audiovisual and technology-supported learning. These findings indicate that digital instructional materials should not only present information interactively but also engage students in inquiry-based learning activities that promote critical thinking.

The task analysis showed that the existing instructional materials were generally aligned with the curriculum but had not yet optimally facilitated contextual problem solving, critical thinking development, or ESD integration. This finding supports previous studies indicating that curriculum alignment alone is insufficient to foster higher-order thinking skills unless instructional materials incorporate authentic learning activities and real-world contexts (Asrizal et al., 2023). Therefore, integrating PBL and ESD into the proposed e-module is expected to bridge the gap between curriculum requirements and students' learning needs.

Taken together, the findings from the concept analysis and instructional objectives analysis indicate that the proposed e-module can be systematically designed according to the hierarchical structure of the linear motion topic while remaining aligned with the Phase F Learning Outcomes of the Merdeka Curriculum. Organizing learning materials from fundamental concepts to more complex applications, together with clearly defined learning objectives, learning activities, and assessments, provides a coherent instructional sequence that supports meaningful conceptual understanding and the development of higher-order thinking skills. This finding is consistent with Erwinsyah et al. (2020), who emphasized that

a systematic conceptual structure is essential for reducing misconceptions in learning linear motion, and with Nisa & Dewi (2025), who reported that curriculum-aligned e-modules can effectively facilitate students' critical thinking skills.

These findings further suggest that effective instructional material development should systematically align curriculum objectives, students' learning characteristics, and sustainability competencies within a coherent instructional design. This perspective is supported by recent reviews emphasizing that effective digital instructional materials depend not only on technological features but also on instructional designs aligned with learners' needs and meaningful learning experiences (Bond et al., 2024). Therefore, the findings suggest that effective digital instructional materials should integrate pedagogical, technological, and sustainability aspects rather than emphasizing technology alone.

Unlike previous studies that mainly examined curriculum alignment, digital teaching materials, Problem-Based Learning, or Education for Sustainable Development as separate instructional components, the present study provides a comprehensive needs analysis showing that a Canva Site-based physics e-module should be designed to address students' critical thinking profiles, learning characteristics, curriculum requirements, PBL syntax, and ESD principles within the context of linear motion learning. This integrated perspective constitutes the primary contribution of the present study because it establishes a stronger empirical foundation for designing innovative physics teaching materials that combine pedagogical, technological, and sustainability dimensions within a unified instructional framework. Consequently, the findings not only justify the necessity of developing the proposed e-module but also extend the existing literature by proposing a needs-based framework for developing digital physics instructional materials that support critical thinking skills and Education for Sustainable Development in secondary science education.

CONCLUSION

The findings of this study highlight the necessity of developing a Canva Site-based physics e-module integrating Problem-Based Learning (PBL) and Education for Sustainable Development (ESD) to enhance senior high school students' critical thinking skills in the topic of linear motion. The needs analysis revealed that existing instructional materials have not adequately supported critical thinking, contextual learning, independent learning, or the integration of sustainability perspectives, while students demonstrated relatively low critical thinking skills and expressed a preference for interactive technology-based learning materials. Furthermore, the front-end, learner, concept, task, and instructional objectives analyses provided a comprehensive empirical foundation for designing an e-module aligned with students' characteristics, curriculum requirements, and sustainability-oriented learning objectives. Therefore, the proposed e-module is expected to foster a more contextual, interactive, and sustainability-oriented physics learning environment while contributing practical insights to the development of innovative digital teaching materials for physics education. Future studies should evaluate the validity, practicality, and effectiveness of the developed e-module in improving students' critical thinking skills and sustainability competencies across diverse learning contexts.

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