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Towards Meaningful Physics Learning: Needs Analysis of an Inquiry-Based E-Module in Secondary Schools for Developing 21st-Century Students' Critical and Creative Thinking Skills

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Abstract: Physics learning at the secondary school level is still largely dominated by theoretical approaches and lacks connection between physics concepts and real-life contexts. This condition hampers the development of students' critical and creative thinking skills, which are essential competencies in the 21st century. Inquiry-Based Lesson is a student-centered approach that has proven effective in fostering these skills through scientific investigation processes. However, the use of digital learning materials based on Inquiry-Based Lesson, particularly in the form of physics e-modules tailored to the characteristics and needs of secondary school students is still very limited. This study aims to analyze the need for the development of Inquiry-Based Lessons physics e-modules from the perspectives of both students and teachers. The research adopts a qualitative descriptive approach, with data collected through questionnaires, interviews, and documentation studies in several secondary schools. The analysis results indicate that most teachers and students require digital learning materials that are interactive, contextual, and capable of systematically facilitating scientific inquiry activities. These findings provide a strong empirical foundation for the development of Inquiry-Based Lesson physics e-modules designed to enhance students' critical and creative thinking skills and to promote more meaningful physics learning.

Keywords: Creative thinking skills; Critical thinking skills; Educational technology; E-Module; Inquiry; Physics learning

Introduction

Ideal physics learning at the secondary school level should be able to build strong conceptual understanding while also fostering higher-order thinking skills, such as critical and creative thinking. In the context of 21st-century demands, the learning process should not only focus on the transfer of knowledge but also on developing students' abilities to solve problems, analyze scientific phenomena, and relate physics concepts to real-life situations. Ideally, physics learning should be carried out through approaches that encourage active student participation in exploring, investigating, and independently discovering scientific concepts through direct experience (Izhar et al., 2023).

21st-century learning emphasizes the development of critical thinking, creativity, collaboration, communication, and digital literacy. Research indicates a growing trend in the use of technology and online learning, particularly after the COVID-19 pandemic. This type of learning highlights active, student-centered methods that continue to evolve in response to the demands of the times.

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21st-century learning emphasizes the development of 4C skills: creativity, critical thinking, communication, and collaboration. Learning is conducted in a contextual manner, relevant to real-world needs, and supported by the use of technology to prepare students for future challenges. In this learning paradigm, teachers act as facilitators, guiding students through meaningful and technology-integrated learning experiences (Martinez, 2022). 21st-century education is characterized by a focus on fostering creativity, critical thinking, communication, and collaboration. Its pedagogical approach encourages active learning that is student-centered and grounded in real-world contexts. Moreover, it aims to enhance students' problem-solving abilities and integrates technology to support and enrich the learning process (Bray, 2023; Xiong et al., 2022).

Critical and creative thinking are essential and complementary 21st-century skills. Critical thinking focuses on logical analysis and evaluation, while creative thinking involves generating new and innovative ideas. Both are necessary for effective problem-solving and adaptation in a rapidly changing world. Education must support the development and assessment of these skills to prepare future generations for emerging challenges (Thornhill-Miller, et al., 2023). Critical and creative thinking act as mediators in the relationship between 21st-century skills and students' problem-solving abilities and academic achievement. In other words, these thinking skills help learners process their learning experiences into concrete solutions to the problems they encounter, ultimately enhancing their academic performance (Almulla, 2023). According to Copeland (2023), critical thinking is the ability to analyze and question arguments in depth, whereas creative thinking is the ability to develop new ideas through open dialogue. These skills encourage students to engage in active and collaborative discussions that foster reflection, evaluation, and innovation in thinking.

Critical thinking is viewed as an active process of deeply evaluating information and arguments, rather than merely recalling or reproducing knowledge. Ellerton (2022) argues that critical thinking and content knowledge should be developed simultaneously, as critical thinking also involves understanding context, evaluating evidence, and applying logical reasoning—all of which can be trained even when content knowledge is still limited. According to O'Reilly et al. (2022) creative thinking is seen as the ability of preschool children to generate new ideas, find alternative solutions, and freely express their imagination. The study highlights that creative thinking is closely linked to the development of critical thinking skills at an early age, where both abilities support each other within an exploratory and reflective learning process in preschool classrooms.

According to Oral et al. (2022), 21st-century skills for physics students emphasize the importance of the 4C competencies: critical thinking, creativity, communication, and collaboration in learning physics. They highlight that success in physics learning depends not only on mastering concepts but also on developing these essential skills to meet the challenges of modern science and technology. Soipimai et al. (2023) emphasize that 21st-century teachers must not only master academic content but also possess communication, collaboration, and technological skills that support effective and relevant learning. By sharing experiences, teachers can strengthen their ability to navigate the dynamic and complex challenges of today's education landscape. Thus, 21st-century teachers act as facilitators who empower students to become active, creative, and adaptive learners. As facilitators, teachers provide diverse and innovative learning resources—one of which is an engaging, interactive e-module tailored to the needs and characteristics of 21st-century learners.

Based on observations and interviews conducted at SMAN 14 and SMAN 15 Medan, empirical findings indicate that physics learning in the classroom is still predominantly characterized by conventional, teacher-centered approaches focused on content mastery and routine problem-solving. This condition limits students' opportunities to develop higher-order thinking skills that are essential for meeting the demands of the modern era. In addition, the availability and use of innovative learning media, such as e-modules Inquiry remain very limited. Yet, such media hold great potential for fostering more meaningful, interactive, and contextual learning experiences. The gap between theoretical frameworks and actual classroom practices highlights an urgent need to conduct a needs analysis for the development of Inquiry-Based Lesson e-modules specifically aimed at enhancing students' critical and creative thinking skills in secondary school physics education.

Although numerous studies have emphasized the importance of developing 21st-century skills—particularly critical and creative thinking in the learning process, implementing effective approaches to achieve these outcomes remains a challenge, especially in the context of secondary school physics education. Inquiry is one approach that has been proven to encourage students to think deeply, ask questions, and solve problems independently. However, from a theoretical standpoint, there is still a lack of research that specifically examines the integration of Inquiry into technology-based learning materials, such as e-modules, particularly those aimed at fostering critical and creative thinking skills in physics learning. Therefore, this study focuses on the development of an Inquiry based physics e-module as a strategic effort to enhance students'

critical and creative thinking skills, specifically targeted at learners in SMAN 14 and SMAN 15 Medan.

The Inquiry model has been widely applied in educational contexts due to its alignment with the principles of active, meaningful, and constructivist learning. Inquiry emphasizes students' active engagement through structured investigations. According to Niesche and Haase, as cited by Rahayuningsih et al. (2023), the Inquiry process consists of seven sequential stages: formulating problems, proposing hypotheses, collecting data, conducting experiments, analyzing data, presenting findings, and reflecting on and evaluating results. These stages guide students in developing critical and creative thinking skills while deepening their conceptual understanding. Furthermore, e-modules, according to Sundari et al. (2024), are highly needed by physics teachers to help students grasp concepts more easily and independently. Digital e-modules are effective for physics learning because they encourage students to be active and critical learners. However, many teachers are still unfamiliar with using e-modules, highlighting the need for training to optimize their implementation. Therefore, combining Inquiry with e-modules is seen as a promising approach to create more effective and meaningful physics learning experiences.

Several previous studies have explored the development of e-modules based on specific instructional models, including Inquiry to improve student learning outcomes across various subjects. For example, the findings of Ramadhani et al. (2024) support the idea that using Inquiry-based e-modules not only enhances students' understanding of the material but also improves their critical and creative thinking skills. Similarly Yusuf et al. (2022) revealed that the implementation of Inquiry through interactive e-modules significantly boosts students' critical and creative thinking abilities by providing a more active and discovery-oriented learning approach.

The findings of Yulkifli et al. (2023) indicate that technology-supported e-modules based on Inquiry can enhance students' competencies, particularly in terms of scientific literacy. Inquiry encourages students to develop critical and creative thinking skills, which are essential for understanding and applying learning concepts effectively. Furthermore Krit et al. (2024) found that the implementation of Inquiry has a positive impact on the critical and creative thinking skills of secondary school students. This study confirms that by providing students with opportunities to ask questions, engage in exploration, and analyze information in depth, Inquiry significantly fosters their critical and creative thinking abilities.

In line with Ariani et al. (2022), the use of Android-based modules integrating the Inquiry Learning approach within a Flipped Classroom model was found to improve students' mathematical problem-solving skills and creative thinking abilities. These findings align with the development of Inquiry based e-modules, which also aim to foster critical and creative thinking skills, as well as promote independent problem-solving. Moreover, research by Nadkarni et al. (2023) reported a high level of satisfaction with the Inquiry format, with 93.4% of participants expressing overall satisfaction. Participants showed strong engagement in several Inquiry phases, including "orientation" (94.6%), "conceptualization" (97.3%), "discussion" (91.1%), and "conclusion" (91.0%). However, engagement during the "investigation" phase was relatively low, at only 48.1%. Qualitative analysis revealed that participants appreciated the principles of active learning, clearly defined objectives, and a safe learning environment that enabled them to broaden their knowledge. This Inquiry program helped learners build deeper understanding through collaborative discussions and the application of theoretical knowledge.

Previous studies have generally focused on only one aspect of thinking skills or were limited to cognitive concept mastery. Many of the developed e-modules have not explicitly and comprehensively integrated the Inquiry model. Furthermore, most of these studies did not begin with an in-depth need analysis of the users (teachers and students) a stage that is essential for producing contextual and applicable learning materials.

Although various studies have explored e-modules and the Inquiry model, there remain several significant gaps. First, many focus solely on developing a single type of thinking skill either critical or creative without integrating both simultaneously. Second, user involvement in the development process, particularly through needs analysis, is still limited. Third, most of the research has been conducted at the junior high school level, whereas physics learning at the senior high school level involves more complex content and higher-order thinking demands. Lastly, the use of technology in the form of interactive e-modules integrated with active learning models like Inquiry is still underutilized.

The urgency of this research arises from real needs observed in the field. Based on classroom observations and interviews with physics teachers at SMAN 14 and SMAN 15 Medan, it was found that instruction still heavily relies on textbooks and lecture-based methods. Students struggle to develop creative ideas and are insufficiently trained in critical information analysis. A major barrier is the lack of innovative teaching materials that align with the characteristics of students in the digital era. Therefore, the development of a physics e-module based on Inquiry is crucial to address these challenges. It also supports the implementation of the Merdeka Curriculum, which emphasizes contextual,

participatory learning and the strengthening of higher-order thinking skills.

Therefore, it is necessary to design and develop a physics e-module based on the Inquiry model, preceded by an in-depth need analysis involving both teachers and students. This e-module will be structured to include learning activities that actively engage students in stages such as orientation, problem formulation, hypothesis development, data collection, hypothesis testing, and drawing conclusions. Through this structured approach, students are expected not only to gain a conceptual understanding of physics but also to develop critical and creative thinking skills in a balanced manner.

This research contributes to two key areas. Theoretically, it enriches the literature on the design of instructional materials based on the Inquiry model in physics education, specifically in supporting the simultaneous development of critical and creative thinking skills. Practically, it produces an e-module grounded in the actual needs of schools, which can be utilized by physics teachers as an innovative teaching medium in the implementation of the Merdeka Curriculum. This study is also expected to serve as a reference for the development of active, contextual, and 21st-century-relevant digital learning materials.

Method

This study represents the initial phase in the development of a physics e-module based on the Inquiry model, focusing specifically on needs analysis as the foundation for designing innovative learning materials. The research design follows the needs analysis model proposed by McKillip (1987). According to McKillip, needs analysis is a systematic process for identifying and prioritizing needs based on the gap between the ideal and actual conditions. Needs are categorized into normative, felt, and expressed needs. This process involves data collection, needs evaluation, and communication of results, making it highly suitable for developing instructional materials such as Inquiry-Based Lesson e-modules that are relevant to user needs (Winarti, et al., 2024).

The approach used in this study is qualitative descriptive, aimed at obtaining an in-depth understanding of the needs of teachers and students for digital instructional materials that are contextual, interactive, and inquiry-based. The research subjects consist of physics teachers and 10th-grade students at SMAN 14 and SMAN 15 Medan, selected using purposive sampling based on their involvement in the physics learning process and their readiness to use digital media.

The data collection technique used in this study involved preliminary study instruments, with data gathered through a triangulation approach. First, questionnaires were distributed to 10th-grade students and physics teachers at two high schools in Medan to collect information regarding learning needs, the extent to which critical and creative thinking skills are developed, and the limitations of current instructional materials used in the learning process. Second, semi-structured interviews were conducted with physics teachers at the same schools to gain deeper insights into their classroom teaching experiences, the challenges faced in developing 21st-century skills, and their expectations for the development of instructional materials based on specific learning models. Third, initial classroom observations of physics lessons were conducted to complement and strengthen the findings from the questionnaires and interviews.

The data collected will be analyzed using a Likert scale approach. The analysis of the preliminary study focuses on a comprehensive needs assessment that includes several key components: the analysis of graduate competency standards, teacher performance, students' learning difficulties, available learning resources, existing teaching materials, instructional models, and the characteristics of the students. In addition, the study analyzes students' critical and creative thinking skills, particularly in relation to their understanding of the topic of global warming. This multi-faceted analysis is intended to identify gaps between ideal and actual learning conditions, which will serve as the foundation for designing an Inquiry e-module that is contextual, interactive, and aligned with the needs of 21st-century learners.

The data analysis technique in this preliminary research is conducted by applying the Likert scale, which is analyzed using the following formula:

$$Score = \frac{Total\ Score\ Obtained}{Maximum\ Possible\ Score} \quad (1)$$

The results of the needs analysis are categorized based on the level of mastery. The categories are presented in Table 1.

Table 1. Categories of Needs Analysis (Arikunto, 2016)

Score Range (%)	Category
80 – 100	Very High Need
70 – 79	High Need
60 – 69	Moderate Need
50 – 59	Low Need
0 – 49	Very Low Need

In the preliminary stage, the researcher conducted a literature review of various previous studies relevant to the development of instructional materials based on

Inquiry, critical and creative thinking skills, as well as the integration of technology in physics education. This review was carried out to strengthen the theoretical foundation for the development of the designed E-Module.

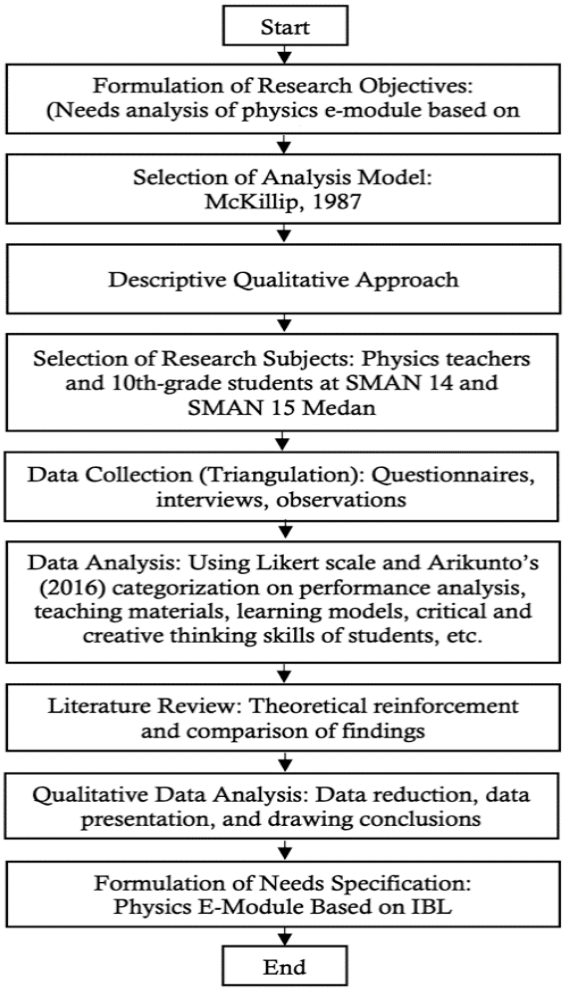

Figure 1. Flowchart of the research procedure

Result and Discussion

Research Results

The initial research conducted at SMA Negeri 14 and SMA Negeri 15 in Medan revealed that, although these schools have implemented the Kurikulum Merdeka, the science learning process remains monotonous. Based on interviews with Mr. Tri Harya Wijaya, S.Si., M.Si., and Mrs. Januarita Ginting, S.Pd who are Physics teachers, one of the main challenges lies in the limited availability of instructional media for Grade 10 Physics. Currently, students only have access to government-issued Physics textbooks which, although sufficient for meeting basic learning needs, lack interactive and exploratory features. As a result, students are less engaged in the learning process and struggle to understand abstract Physics concepts.

The lack of variety in instructional materials also affects students' opportunities to develop critical and creative thinking skills. The dominance of monotonous and unengaging learning approaches tends to make students passive recipients of information, with limited opportunities to practice analyzing, problem-solving, or connecting concepts to real-life contexts. The preliminary analysis was conducted to identify the needs of both students and teachers in various aspects of the learning process at the two schools.

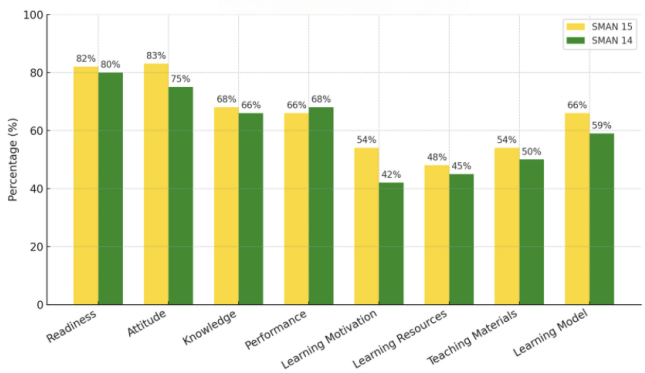

Figure 2. Diagram of teachers' needs analysis results

Analysis results presented in the diagram indicate that physics learning at SMAN 14 and SMAN 15 Medan has not yet fully achieved meaningful learning goals. Based on the bar chart in Figure 2, it can be seen that the analysis of graduate competency standards shows that religious competence has an average score of 79%, categorized as high; attitude competence has an average score of 84%, categorized as very high; and knowledge competence has an average score of 63%, categorized as moderate. Furthermore, the analysis of teacher performance shows an average score of 68%, which also falls into the moderate category. Meanwhile, the analysis of students' learning difficulties yields an average score of 48%, categorized as very low. This indicates that students face significant challenges in understanding the material, highlighting the need for the implementation of appropriate learning models to improve their comprehension.

The analysis of learning resources shows an average score of 50%, which falls into the low category, while the analysis of teaching materials shows a score of 48%, categorized as very low. This indicates that the teaching materials used are still suboptimal, primarily because most of them are in the form of textbooks without a clear scientific approach. The content presentation, which mainly consists of theoretical explanations, example problems, and end-of-chapter exercises, is insufficient in developing students' creative thinking skills. Furthermore, the analysis of learning models yields an average score of 63%, which is categorized as moderate. This suggests that in the

learning process, teachers still frequently rely on conventional methods without implementing effective instructional models.

Overall, the main contributing factor to this condition is the continued dominance of conventional teaching approaches that do not accommodate the learning needs of 21st-century students. The material presented tends to be theoretical, lacking context, and provides minimal exploratory activities that could foster deeper thinking. In addition, the limited availability of innovative teaching materials and lack of variety in learning resources further exacerbate students' learning difficulties. Therefore, it can be concluded that the physics instruction currently implemented has not been fully effective in developing students' conceptual understanding and higher-order thinking skills.

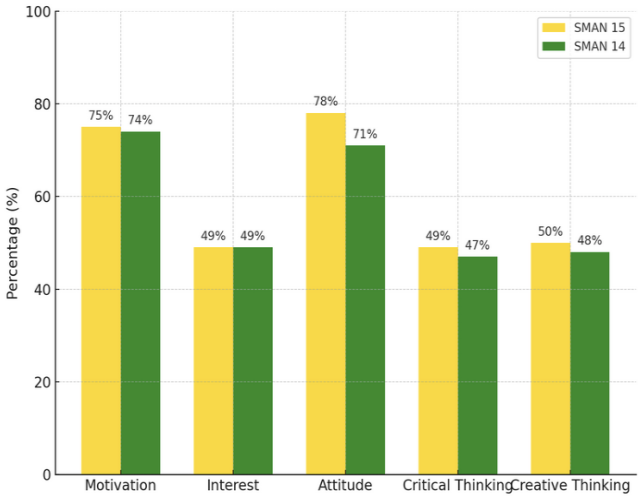

Figure 3. Diagram of students' needs analysis results

Based on the bar chart in Figure 3, it can be seen that, in general, students demonstrate relatively high levels of motivation and attitude toward physics learning. The average percentage for the motivation aspect is 74.5%, categorized as high, and the average percentage for attitude is 77.5%, also in the high category. These two aspects indicate that students at both schools have enthusiasm and a positive disposition toward physics. However, other aspects such as interest, critical thinking, and creative thinking show significantly lower percentages. The average percentage for student interest is 48.5%, categorized as very low; the critical thinking aspect has an average score of 48%, also categorized as very low; and the creative thinking aspect has an average of 49%, likewise in the very low category.

These data indicate that although students have enthusiasm and a positive attitude toward learning, their higher-order thinking skills particularly critical and creative thinking have not yet developed optimally. The low averages in these three aspects form a crucial foundation for designing more meaningful and challenging learning experiences. This condition reflects the ongoing challenges in physics education, which remains largely conventional and tends to focus on lower-order cognitive skills, such as memorizing formulas or solving problems procedurally. Students are not yet fully provided with opportunities to explore, reason, and create solutions in real-life contexts. This hinders the achievement of truly meaningful learning, which occurs when students are able to connect physics concepts with phenomena in their surroundings and develop complex thinking skills.

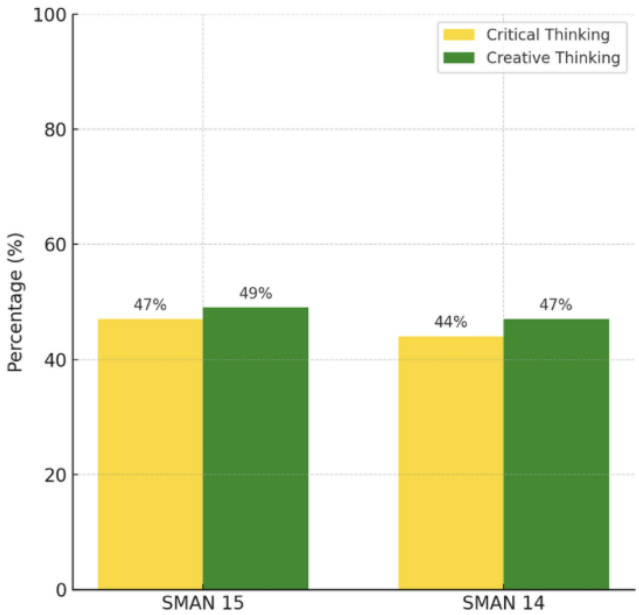

Figure 4. Diagram of the analysis results on critical and creative thinking skills in the topic of global warming

Based on the bar chart in Figure 4, the analysis of students' critical and creative thinking skills in understanding the topic of global warming shows that these skills among students at SMAN 14 and SMAN 15 Medan are still relatively low. The average critical thinking skill score is only 45.5%, while the average creative thinking skill score is 48%. At SMAN 15, the critical thinking score is 47%, and creative thinking is 49%. Meanwhile, at SMAN 14, critical thinking is at 44% and creative thinking at 47%. Although the differences are not highly significant, they indicate that both schools still face challenges in fostering higher-order thinking skills among students.

Critical and creative thinking skills are essential for understanding and learning the topic of global warming, as this subject requires not only conceptual understanding but also the ability to analyze cause-and-effect relationships, evaluate information, and generate solutions to environmental problems. In the context of critical thinking, students are expected to identify the causes of global warming, assess its impact on life, and

evaluate policies or actions taken by individuals and governments. Meanwhile, creative thinking skills are needed so that students can develop innovative and practical ideas, such as creating environmental campaigns, designing eco-friendly technologies, or formulating strategies for reducing carbon emissions that can be applied in daily life.

Discussion

Physics learning at the secondary school level has specific characteristics that emphasize conceptual understanding and the application of science in everyday life. However, in practice, physics material is still often presented theoretically with minimal exploratory activities. This has resulted in higher-order thinking skills, such as critical and creative thinking, not being optimally developed. Therefore, an instructional innovation is needed to bridge this gap through a more active and contextual learning approach.

Curriculum Analysis and Technological Relevance

Current global issues have influenced the implementation of curricula in the digital era, particularly with regard to the digital divide, inequalities in distance learning delivery, and infrastructural limitations across regions. These conditions highlight the urgency for reform both in the education system and in curriculum content. Khoza et al. (2022) indicated that the pandemic compelled academics at universities to shift toward a digital curriculum that integrates performance- and competency-based approaches. The implementation of digital curricula was successful due to the support of values such as integrity and collaboration, as well as the availability of educational technology. This study emphasizes the importance of institutional readiness and support in the successful implementation of digital curricula.

A study conducted by Vreuls et al. (2022) emphasizes the importance of responsive curriculum development in professional education. The research highlights that curriculum development teams adopt various approaches, dynamics, and face different challenges in responding to labor market demands and social changes. The success of curriculum development does not rely solely on its structure but also depends on cross-disciplinary collaboration, stakeholder involvement, and the ability to adapt to external changes. The curriculum must provide space and resources for teachers to develop technological competencies, while also ensuring that technology education becomes an integral part of the teaching and learning process. Teacher training and the provision of equipment must be aligned with curriculum requirements so that educators can implement technology education effectively. Furthermore, poorly integrated curricula also result in a lack of training and resources available to teachers for effectively delivering technology-related topics (Pappa, 2024).

Al-Dababneh et al. (2022) stated that teachers' beliefs and professionalism play a crucial role in the implementation of assistive technology for children with specific learning difficulties in inclusive settings. The integration of technology into the inclusive curriculum helps meet the individual needs of students, enhances accessibility, and supports the achievement of learning objectives. Therefore, the curriculum must be adaptively designed with technological support to realize true inclusivity and equity in education. Furthermore, the study by Dilekçi et al. (2023) shows that a 21st-century skills-based curriculum is effective in improving students' creative thinking abilities. In relation to curriculum and technology development, these findings underscore the importance of integrating technology into learning to support the development of creativity, collaboration, and critical thinking the core competencies of 21st-century skills.

The implementation of digital technology in secondary schools has shown a tangible positive impact, especially in enhancing teachers' skills and confidence. With access to digital devices and interactive learning platforms, teachers are better equipped to design varied and relevant learning experiences that meet students' needs Varkey (2023) emphasizes the importance of flexible instructional design, effective use of technology, and continuous assessment to ensure meaningful and relevant learning experiences for students in the digital era. This approach allows students to learn at their own pace and time, while still maintaining the quality and depth of the content delivered. Similarly, findings from Khlaisang (2023) show that most teachers have a positive attitude and are receptive to using mobile technology in the learning process. Factors such as perceived ease of use, perceived usefulness, and institutional support significantly influence the acceptance of such technology.

The success of digital technology integration in secondary schools greatly depends on the combination of teachers' technical and pedagogical skills. Teachers with digital competence are not only able to operate technological devices but also capable of designing relevant and interactive learning processes. Research findings indicate that improving teachers' digital pedagogical competence has a positive impact on the quality of student learning (Bentri, et al., 2022). This is in line with Nanjundaswamy et al. (2021), who state that with sufficient pedagogical mastery, teachers can adapt the use of technology to meet students' needs, creating a more effective and engaging learning experience. This enables students to become more actively involved in

their learning process. Moreover, the proper use of technology can support the development of critical thinking and collaboration skills, which are essential in the modern era.

Characteristics of E-Modules Relevant to Emerging Technologies

E-modules that align with current technological advancements must offer interactive, flexible, and adaptive learning tailored to the needs of 21st-century learners. Beyond delivering theoretical content, such e-modules should provide systematic guidance to help students carry out real-world projects. These collaborative activities encourage students to exchange ideas, engage in discussions, and work together to solve problems encountered during the learning process. Dewantara et al. (2021) emphasize that interactive features such as simulations, animations, videos, auto-graded quizzes, and non-linear navigation are crucial in physics e-modules. These features have been proven to enhance student engagement, conceptual understanding, and science process skills. This article supports the trend of using interactive e-modules effectively in distance learning environments. Furthermore, research by Komikesari et al. (2020) developed an e-module using Flip PDF Professional, which includes interactive features such as flipbook effects, animations, videos, hyperlinks, and digital practice questions. These features help increase student engagement and understanding, particularly in topics like temperature and heat.

More than just a learning medium, e-modules also support the development of critical thinking, creativity, and problem-solving skills. Projects embedded within e-modules provide space for students to innovate while receiving constructive feedback. In this way, e-modules enhance conceptual understanding while also equipping students with practical skills that are useful in real-life contexts (Albana & Sujarwo, 2021). This aligns with the findings of Sari et al. (2024), who state that e-modules can also increase learning motivation through engaging and interactive content delivery, making them a relevant tool in modern education.

Research by Waluya et al. (2022) states that e-modules are effective teaching materials and are feasible to be used as innovative learning media that support the advancement of educational technology in the digital era. Furthermore Tjiptady et al. (2022) show that Android-based e-modules leverage technology to support distance learning through a Life-Based Learning approach, thereby increasing student engagement and motivation through relevant content that is easily accessible anytime. In line with this, Habibi et al. (2024) emphasize the importance of technology-based e-modules that are relevant to the needs of the 21st century, especially for vocational high school students. The development of interactive and adaptive e-modules using digital technology can enhance student engagement and skills throughout the learning process. With technology as the foundation, e-modules promote more effective, flexible, and future-ready learning aligned with the digital age. Thus, technology acts as the main enabler in creating innovative and effective e-modules for modern education.

Indicators of Critical and Creative Thinking Integrated with Inquiry

To enable the development of critical thinking skills, an e-module must incorporate indicators of critical thinking. According to Anggraeni et al. (2023), critical thinking includes the ability to analyze, evaluate, draw conclusions, interpret information, explain reasoning, reflect on the thinking process, solve problems, and make decisions. Similarly, Trúsiková et al. (2022) state that critical thinking indicators in physics experiments involve observing, asking questions, analyzing data, evaluating evidence, drawing conclusions, and reflecting on the process. These indicators are essential for enhancing students' critical thinking skills in physics learning. Activities in the e-module can include case studies, open-ended questions, virtual experiments, and assignments that require students to construct arguments or compare various concepts.

To develop creative thinking skills, the indicators of verbal creative thinking according to López Martínez et al. (2024) should include fluency, flexibility, originality, elaboration, problem sensitivity, opacity, dynamic integration, and idea refinement. These are assessed through tasks such as problem formulation, idea generation, and idea improvement. Furthermore Putri et al. (2023) state that creative thinking indicators include fluency, flexibility, originality, and elaboration, which assess students' abilities to generate many ideas, think from multiple perspectives, create novel ideas, and develop ideas in detail. Similarly Mursid et al. (2022) emphasize that the indicators of creative thinking also comprise fluency, flexibility, originality, and elaboration, particularly in the context of engineering problem-solving, which supports improved student learning outcomes through the application of the blended project-based learning model. These indicators can be realized in the e-module through activities such as creative projects, experimental design, scenario-based interactive simulations, and exploratory tasks grounded in real-life contexts.

The study by Desnita et al. (2022) demonstrated that e-modules are significantly effective in enhancing high school students' creative and critical thinking skills. The use of e-modules also had a positive impact on students'

physics learning outcomes, which were higher compared to those of students who learned without the aid of e-modules. Similarly, the research by Serevina et al. (2022) showed that Android-based e-modules were more effective in improving students' critical thinking skills than printed modules, with an effect size of 0.67 (moderate category). These e-modules were particularly helpful for online learning during the pandemic. Furthermore Yulkifli et al. (2023) found that an Inquiry e-module supported by smartphones, developed for static fluid material, was valid and feasible for use. The implementation of this e-module effectively improved students' scientific literacy and competence, thereby contributing to the enhancement of technology-based and science-literate physics education.

In Inquiry students are encouraged to ask questions, conduct investigations, collaborate, and analyze and reflect on their findings. This process involves group collaboration, where students share insights and build collective understanding. The results of these investigations are then summarized and communicated, either through reports or presentations. Inquiry aims to develop students' critical and creative thinking skills through hands-on experiences that are relevant to real-world contexts (Sam, 2024). E-modules based on Inquiry are highly effective in fostering students' critical and creative thinking. Through this approach, the e-module not only delivers content but also actively cultivates students who think critically and creatively.

Comprehensive Needs Analysis Based on McKillip's Framework

Primary Users of the E-Module

The primary users of the physics e-module developed based on the Inquiry model consist of two key groups: teachers and students at the secondary school level. Teachers, particularly physics teachers, play a central role as facilitators in 21st-century learning. They are not only responsible for delivering content but also for designing active, collaborative, and contextual learning experiences. In today's digital context, teachers are also expected to possess adequate digital and pedagogical literacy in order to effectively integrate technology into the teaching and learning process.

Students are the direct recipients of the instructional intervention designed through the e-module. They are part of the digital native generation, accustomed to using technological devices and digital applications in their daily lives. Therefore, the learning media employed must align with their characteristics interactive, flexible, visually engaging, and cognitively challenging. Observational and interview data from SMAN 14 and SMAN 15 Medan indicate that although students demonstrate positive motivation and attitudes toward physics, they still lack adequate access to instructional materials that effectively support the development of critical and creative thinking skills.

Therefore, the development of this e-module is intended to address the needs of both user groups: assisting teachers in delivering structured inquiry-based instruction, and providing students with engaging and challenging learning media

Inquiry to Enhance Critical and Creative Thinking Skills

The primary objective of developing this e-module is to improve the quality of physics instruction at the secondary school level by promoting the development of students' critical and creative thinking skills through the Inquiry approach. Critical and creative thinking are key 21st-century competencies that are essential for the younger generation to face the complexities of global challenges, technological advancements, and future workforce demands. Critical thinking involves the ability to analyze, evaluate, interpret, and make decisions based on available evidence. Meanwhile, creative thinking includes the ability to generate new ideas, find alternative solutions, and view problems from multiple perspectives. These two skills are not only relevant in academic contexts but are also crucial in everyday life.

An e-module based on Inquiry serves as an effective medium to achieve this goal, as the inquiry approach emphasizes an active, collaborative, and reflective scientific thinking process. Through stages such as formulating problems, proposing hypotheses, conducting observations, analyzing data, and drawing conclusions, students are trained to think critically and creatively in an integrated manner. The long-term objective is to create meaningful and contextual physics learning experiences that enhance students' competitiveness in the global era.

Identified Real Needs

Physics learning still faces various challenges, particularly in terms of the availability of innovative teaching materials. Both teachers and students reported that the current learning modules tend to be conventional, lack interactivity, and have not effectively supported the development of critical and creative thinking skills. Teachers expressed that they have not received adequate training on the implementation of the Inquiry model, and no digital modules are currently available to systematically guide the application of this approach. On the other hand, students demonstrated good enthusiasm toward learning physics; however, their levels of critical thinking, creativity, and learning interest remain relatively low. This indicates that the current instructional approach has not yet fully

succeeded in fostering active student engagement and deep understanding.

Therefore, there is a need for learning media such as an interactive, contextual Inquiry-Based Lesson e-module, designed in alignment with the characteristics of 21st-century learners. Such a module is essential to address current instructional challenges and to support the continuous enhancement of higher-order thinking skills.

Urgent Development Priorities

The most urgent development priority is the creation of an interactive digital learning medium in the form of a physics e-module based on Inquiry. This need arises due to the dominance of conventional teaching materials, which fail to sufficiently promote active participation, contextualization of content, and the development of higher-order thinking skills. The e-module to be developed must present content in a visual and interactive manner, incorporating features such as simulations, videos, animations, auto-graded quizzes, and flexible navigation, all of which align with the learning characteristics of 21st-century students.

The module should be developed following the stages of Inquiry, namely orientation, problem formulation, hypothesis development, data collection and analysis, followed by conclusion and reflection. This structure is intended to foster integrated critical and creative thinking in students. The activities within the module should include analytical exercises, case studies, and exploratory projects that stimulate new ideas and innovative solutions. Furthermore, the e-module must be flexible enough to be implemented in face-to-face, hybrid, or online learning settings, and should include user guides for teachers. Accordingly, the development of this e-module represents a strategic priority to support physics instruction that is more meaningful, contextual, and aligned with the Merdeka Curriculum as well as 21st-century skill demands.

Strategic Decision for Development Solution

The strategic decision in this study is to develop a physics e-module based on Inquiry that aligns with the needs and characteristics of its users. This decision is grounded in its alignment with 21st-century curriculum demands particularly the Merdeka Curriculum, which emphasizes contextual and competency-based learning as well as in the proven effectiveness of the Inquiry model in fostering critical and creative thinking skills, as supported by prior research. Furthermore, the development of this digital e-module is a response to the post-COVID-19 digital education transformation and is expected to enhance the overall quality of physics instruction. The e-module is also designed to serve as a tool for pedagogical transformation, enabling teachers to act as facilitators of active and reflective learning. This educational innovation is therefore both relevant and applicable to real-world classroom needs.

Conclusion

Based on the overall analysis presented through the three diagrams, it can be concluded that physics instruction at SMAN 14 and SMAN 15 Medan has not yet fully achieved meaningful and contextual learning objectives. Although students demonstrate motivation and a positive attitude toward learning physics, this has not been accompanied by the development of higher-order thinking skills particularly in critical and creative thinking, which remain at very low average levels. This condition is largely due to the continued use of conventional teaching approaches, the lack of diverse instructional materials, and the limited number of activities that encourage exploration and in-depth understanding. A similar condition is observed in the learning of the global warming topic, which ideally should foster higher-order thinking skills, but has not yet been utilized optimally. Therefore, there is a need for the development of innovative instructional materials, such as an Inquiry Based Lessons e-module, which can promote more active, reflective, and contextual learning, while also enhancing students' critical and creative thinking skills. Physics learning at the secondary school level requires innovation to become more contextual and to promote higher-order thinking skills. The integration of digital technology such as Inquiry Based Lessons e-modules—has proven effective in creating interactive, collaborative, and relevant learning experiences. Well-designed e-modules can foster critical and creative thinking skills through exploratory and project-based activities. The integration of technology into the curriculum, along with the enhancement of teachers' digital competencies, is key to developing an adaptive education system that meets global challenges and 21st-century demands.

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