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Learners' Needs for E-Modules in Dynamic Fluid Learning Integrated with 21st Century Skills

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Abstract: This study aims to describe the need for developing electronic-based teaching materials (e-modules). The research is a descriptive study conducted at a high school in Padang City, involving 140 students as participants. A questionnaire was used as the data collection instrument to assess students' needs for teaching materials and their characteristics. The questionnaire includes five indicators: 1) student characteristics, 2) implementation of physics learning, 3) use of teaching materials in physics lessons, 4) students' needs for teaching materials, and 5) students' 21st-century skills. The data collected were analyzed using descriptive statistics. The findings revealed that 1) 67% of students struggle with physics lessons, 2) 53% of students reported that feedback from teachers at the end of physics lessons is inadequate, 3) 45% of students have not used diverse teaching materials, 4) 80% of students need additional learning resources, such as teaching materials with text, images, and videos, for independent study, and 5) 51% of students have low 21st-century skills. These results underscore the need for developing electronic teaching materials (e-modules) to support physics learning.

Keywords: E-module; Learning physics; Needs analysis; Teaching materials

Introduction

Physics learning today demands the integration of technology and innovative learning models to meet the needs of diverse students. One relevant approach is the application of an open inquiry-based learning model, which emphasizes active student involvement through the process of scientific investigation (Supriadi & Ratnawulan, 2019). This model consists of several syntaxes, namely identifying problems (identify problem), formulating hypothesis (formulate hypothesis), designing experiments (plan investigation), carrying out experiments (conduct investigation), analyzing data (analyze data), and drawing conclusions (draw conclusion) (Kuhlthau et al., 2007). This approach not only improves concept understanding but also supports the development of 21st century skills, which include communication, collaboration, critical thinking, and creativity (4C).

Physics as a subject that focuses on calculation, reasoning, and logic skills is often considered difficult by students. Students often face difficulties understanding abstract concepts, especially in materials such as dynamic fluids that require visualization and complex mathematical analysis (Istyowati et al., 2017). This difficulty is often exacerbated by the lack of teaching materials that support in-depth exploration of concepts. Most of the teaching materials used today are still in printed form and are not equipped with adequate interactive features to encourage independent learning (Gumilar & Effendi, 2022).

One of the physics topics that students often find challenging is dynamic fluids (Novitasari, 2016). The difficulty in grasping the concept of dynamic fluids arises from variations in students' initial understanding

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(preconceptions) of the material (Fauza et al., 2023). While some students' perceptions align with the correct concept, others hold misconceptions. If the learning process is not guided properly, these misunderstandings can persist, leading students to maintain incorrect concepts (Papilaya & Tuapattinaya, 2022). Among the challenges students face in understanding dynamic fluid concepts are the sub-topics of the continuity equation, Bernoulli's principle, and the application of pressure and fluid flow concepts in real-life situations, which are often not well understood (Deni, 2018). Understanding dynamic fluids requires a solid grasp of pressure (Mussani et al., 2015), flow velocity, and fluid energy. However, to fully comprehend these relationships, students must first master the basic concepts of fluid properties and hydrostatic pressure (Hafizah et al., 2018).

The application of dynamic fluid principles, such as Bernoulli's equation, is essential for students to solve various real-world problems, including fluid flow through pipes, fluid sprays, and the design of hydraulic systems in daily life. Additionally, the difficulty level of physics concepts is influenced by the teaching materials used by students (Gumilar & Effendi, 2022). Most physics learning resources are still in printed form, and they often present content in complex language that students find difficult to comprehend, hindering their ability to construct knowledge independently (Kurniawan et al., 2018). As a result, teachers are expected to be innovative in designing teaching materials to make physics lessons more engaging and ensure that students fully grasp the concepts presented.

An efficient, structured, and effective learning process can be achieved by utilizing alternative teaching materials (Kasih et al., 2021), one of which is electronic-based resources such as e-modules (Rahmatullah et al., 2023). E-modules are digital learning tools that offer several advantages over printed modules, including the integration of audio, video, images, animations, and quizzes (Hidayat et al., 2020). They also provide automatic feedback, making it easier for students to engage in independent problem-solving (Cheva & Zainul, 2019). In addition, e-modules are accessible across various devices, such as computers, laptops, tablets, and smartphones (Nurmayanti et al., 2015). The use of e-modules offers an effective approach to enhancing the quality of student learning through engaging and systematic content presentation. According to Puspitasari et al. (2020), e-modules are learning tools designed electronically to deliver materials in an organized and appealing way, aimed at helping students achieve the desired competencies (Putri et al., 2019).

Electronic teaching materials, such as e-modules, offer several advantages. First, they present learning content and practice questions in diverse formats, not limited to text but also incorporating images and videos that enhance understanding of the material. Second, e-modules provide flexibility, allowing students to learn at their own pace and according to their needs (Puspitasari et al., 2020). However, one drawback is that many existing e-modules have not been optimized to improve students' comprehension of physics concepts (Setiawati et al., 2018). Therefore, their effectiveness can be maximized when combined with an appropriate learning model that supports the use of e-modules (Kasih et al., 2021).

One of the learning models that allows students to use modules is the open inquiry learning model. This learning model can be implemented in physics learning modules to help students develop critical thinking skills and creativity (Cai et al., 2021; Liew & Treagust, 1998). The open inquiry learning model is designed to encourage students to be actively involved in the scientific investigation process through learning syntaxes which include: (1) formulating problems, where students are expected to identify and formulate research questions independently, (2) designing experiments, where students develop procedures and determine the tools and materials needed to test hypotheses, (3) conducting experiments, where students actively collect data and observe experimental results, (4) analyzing data, where students process observations to draw conclusions, and (5) communicating results, where students convey their findings in the form of reports or presentations (Kuhlthau et al., 2007; Liew & Treagust, 1998; Pizzolato et al., 2014). This learning model allows students to interact directly with physics concepts through guided or independent investigations, thus helping them understand concepts deeply and contextually. By applying the open inquiry learning model, teachers can encourage students to overcome misconceptions, improve analytical thinking skills, and practice the scientific method in solving physics problems (Zeidan & Jayosi, 2015).

The use of digital teaching materials, such as e-modules based on open inquiry, can be a solution to improve the effectiveness of physics learning. E-modules have various advantages, such as the ability to present material through text, images, videos, and animations, which support various learning styles of students. In addition, e-modules allow students to learn independently with minimal guidance from the teacher, facilitating the exploration process in accordance with the open inquiry syntax (Nurmayanti et al., 2015). With the open inquiry learning model, students not only understand physics concepts but also develop 21st century skills, such as critical thinking in analyzing experimental data, communicating effectively when discussing results, collaborating in groups, and producing creative solutions to physics problems (Malina et al., 2021).

Method

This study was a descriptive research, aimed at systematically and accurately depicting the facts and characteristics of the object under investigation (Sukardi, 2004). The procedure of this research is illustrated in Figure 1.

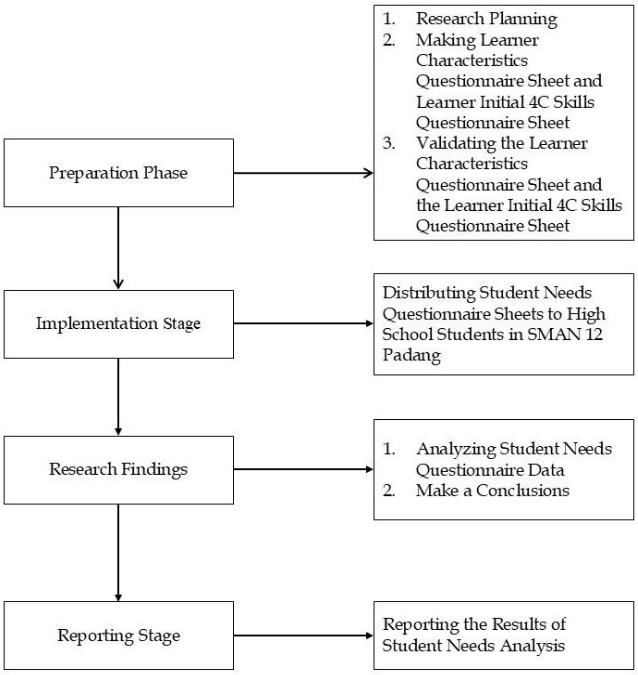

Figure 1. Research procedure

The instrument used for data collection was a questionnaire aimed at identifying students' characteristics and their 4C (critical thinking, communication, collaboration, and creativity) skills. This questionnaire was designed to gather information regarding students' needs and the types of teaching materials they use during physics lessons. The data collection process took place at a high school in Padang City, involving 140 students who were selected randomly as research participants. The collected data on student needs were then analyzed using descriptive statistical methods. Descriptive statistics provide an overview of the research object by summarizing data from a sample or population (Sugiyono, 2014).

Result and Discussion

This study aimed to identify students' needs for teaching materials that support physics learning. Data were collected from 140 students through an online questionnaire distributed via Google Forms. The student questionnaire instrument consisted of five key components: (1) student characteristics, (2) the implementation of physics learning, (3) the use of teaching materials in physics lessons, (4) student needs related to teaching materials, and (5) students' 21st-century skills. The organization of data from the student needs questionnaire is presented in Table 1.

Based on Table 1, it can be seen that 70% of students enjoy learning physics, yet 67% of them face difficulties in understanding the material, and 69% struggle with solving physics problems. Several factors contribute to these challenges, including students' lack of mastery of the subject matter and the perception that physics is one of the most difficult subjects in school (Ma'rifa et al., 2016). Additionally, 71% of students have trouble comprehending physics lessons due to a learning process that is more teacher-centered, where teachers dominate the classroom by delivering explanations while students passively listen (Mujahida & Rus'an, 2019). This approach limits students' opportunities to actively engage and develop their potential (Istyowati et al., 2017).

Table 1. Characteristics of Learners

Indicator	Students' Response
Characteristics of Learners	• Enjoy learning physics (70%) • Difficulty understanding (67%) and taking a long time to understand (71%) physics concepts • Difficulty solving physics questions (69%) • Knowing about audio (83%), visual (82%), video (85%), and virtual laboratory (71%) • Easy to understand the material when audio (65%) is presented, media images and diagrams (75%), learning videos (80%), and virtual laboratory (66%) • Keen on e-modules accompanied by videos (71%), animations (75%), and virtual laboratory (68%) • Proficient in using technology (smartphone/ computer) (76%)

In the current era, education is strongly influenced by technological advancements, and 76% of students are already familiar with technology (Utami & Yuwaningsih, 2020). Students are aware of the use of audio (83%), visual aids (82%), videos (85%), and virtual laboratories (71%) in learning. They express a need for additional teaching materials that are accessible and easy to understand (Maslahah & Rofiah, 2019). Learning becomes more effective when physics content is supported by audio (65%), images and diagrams (75%), videos (80%), and virtual labs (66%).

Most students prefer electronic-based modules (e-modules) integrated with videos (71%), animations (75%), and virtual laboratories (68%) to enhance their understanding of physics concepts. E-modules enriched with multimedia components can serve as effective learning tools to help students grasp complex materials more easily and stay motivated (Tahya et al., 2022). These modules provide opportunities for students to engage in independent learning using supportive features such as text, images, virtual labs, and learning videos (Herawati & Muhtadi, 2018). By incorporating such elements, students can better comprehend the physics material and improve their learning outcomes.

Table 2. The Implementation of Physics Learning

Indicator	Student Response
The Implementation of Physics Learning	• Teacher-centered (79%) • Orienting (65%), formulating hypotheses (51%), designing experiments (41%), carrying out experiments (70%), analyzing data (71%), and drawing conclusions (73%) • Getting feedback from the teacher (53%) • Evaluation in the form of conceptual questions (49%) and calculation questions (78%)

Based on Table 2, the researcher obtained the results of the physics learning implementation indicators, namely from a total of 221 students suggested that most of the physics learning in the classroom is still dominated by the teacher-centered approach (79%), where the teacher acts as the center of information and teaching. This shows that students are less given the opportunity to explore the material independently and actively. The physics learning process that is more based on constructivism approaches such as Open Inquiry, which prioritizes student involvement in hypothesis formulation, experimentation, and data analysis, is still rarely applied optimally. Based on the data, students involved in orienting (65%) and formulating hypotheses (51%) show a lower level of involvement compared to other activities such as carrying out experiments (70%), analyzing data (71%), and drawing conclusions (73%). This indicates that although experimentation and data analysis are important parts of physics learning, students are still less involved in the early stages such as orienting the problem and formulating hypotheses, which are important syntax in the Open Inquiry model.

In terms of evaluation, students are still given more calculation questions (78%) compared to conceptual questions (49%), which reflects the focus of learning more on mastering calculation techniques rather than in-depth understanding of concepts. In fact, concept-based evaluation will encourage students to think more critically and understand the relationship between physics theory and applications in everyday life (Chin & Brown, 2000). In addition, the data also shows that 53% of students get feedback from teachers, but this is not enough to ensure that students really get the necessary guidance to develop their critical thinking. The development of Open Inquiry-based physics e-modules with syntaxes such as Identify, Hypothesize, Plan, Experiment, Analyze, Conclude will help address the problem by giving students the opportunity to be actively involved in the entire learning cycle. With e-modules, students not only receive knowledge, but are also engaged in a process of inquiry that can improve conceptual understanding and 21st century skills, such as critical thinking, problem solving, and creativity (Jonassen et al., 2008). This e-module will provide an opportunity for students to do more problem-based learning, strengthen their understanding of concepts through exp.

Table 3. The Use of Teaching Materials in Physics Learning

Indicator	Student Response
The Use of Teaching Materials in Physics Learning	• Using printed-teaching materials (74%) • Using teaching materials made by teachers (39%) and varied-teaching materials (45%) • Have not used digital-based teaching materials (73%) • Feeling that teaching materials are used insufficiently as learning resources (64%)

Based on Table 3, 74% of the teaching materials used in schools are in printed form. These printed materials are generally informative but simple, focusing primarily on practice questions without providing comprehensive explanations (Puspitasari, 2019). According to Oktavia et al. (2020), the content structure and presentation of printed teaching materials need improvement to make them more appealing. However, the material in printed resources tends to be abstract and difficult to understand, causing students to lose interest in reading them (Rachman, 2018). As a result, students struggle to expand their knowledge even when printed teaching materials are available (Kurniawan et al., 2018).

Observations indicate that only 39% of teachers create their own teaching materials, and the use of diverse teaching resources remains limited, with only 45% of teachers incorporating varied materials in their lessons. This lack of variety highlights the need for additional teaching materials that students can understand and study independently. Furthermore, 64% of students feel that current learning resources are insufficient, and 73% express a desire for technology-assisted teaching materials, such as e-modules. E-modules encourage students to engage in self-directed problem-solving with minimal guidance from teachers, making them a valuable tool for supporting independent learning (Maslahah & Rofiah, 2019).

Table 4. Students' Needs for Teaching Materials

Indicator	Student Response
Students' needs for teaching materials	• Understanding the material quickly if the teaching materials are made by the teacher (75%) • Using digital-based teaching materials (49%) • Requires teaching materials that can lead to prediction, observation, and explanation (77%) • Requires teaching materials for independent study (80%) • Requires teaching materials to be accessed by smartphone/computer (76%) • Enjoyed e-modules (82%) • Requires feedback in e-module (82%)

Based on the data presented in Table 4, which highlights indicators of student needs for teaching materials, it can be concluded that understanding students' preferences for teaching resources is essential. 75% of students find that teacher-made teaching materials are easier to comprehend in physics learning. However, 49% of students have never used e-modules, and 77% express the need for e-modules that can help develop their 4C skills (critical thinking, communication, collaboration, and creativity) in relation to physics content. Additionally, 80% of students prefer electronic-based teaching materials that allow for independent learning.

E-modules encourage students to solve problems through self-directed approaches, requiring minimal teacher intervention (Maslahah & Rofiah, 2019). Furthermore, 82% of students agree that integrating digital teaching materials into physics learning would be beneficial. However, the data also reveals that 82% of teachers have not provided direct feedback during learning evaluations. Feedback plays a crucial role in learning by serving as an external stimulus that helps students correct misconceptions and improve their understanding (Rahma et al., 2020; Nuri et al., 2023; Rahmatullah et al., 2023; Susanto et al., 2022). The lack of feedback is primarily due to limited classroom time, making it difficult for teachers to provide individualized feedback to a large number of students (Hamid et al., 2013).

Table 5. 21st Century Skills of Learners

Indicator	Student Response
21st Century Skills of Learners	Collaboration • Able to manage group work (51%) in solving problems (47%) and giving advice to groupmates (49%) • Helping peers (64%) Critical Thinking • Recognizing own strengths and weaknesses in the group (56%) • Feedback on peer arguments (53%), flexible knowledge (54%) and interpreting information (64%) Creative Thinking • Able to provide ideas clearly (54%), original (53%), and unique thinking (54%) • Gathering various data information in solving problems (45%) Communication • Able to use appropriate communication (64%), formal language style (52%) and formal body language (67%) • Able to listen actively when peers speak (70%)

Based on the data obtained depicted in Table 5, with 21st century skills indicators, that the level of student collaboration shows that 51% of students are able to manage group work, 47% are effective in solving problems, and 49% are able to give advice to groupmates. However, there is great potential to improve the ability to help peers who have reached 64%. Through open inquiry syntax, such as Identify Problem and Plan Investigation, students are encouraged to work collaboratively, share responsibilities, and provide input to each other in solving physics problems (Anderson, 2002). In terms of critical thinking, 56% of students were able to recognize their own strengths and weaknesses in the group, while 53% had provided feedback on their friends' arguments.

This can be optimized through the Analyze Data and Conclude syntax, where students analyze information, provide data-based arguments, and interpret information flexibly, as 64% of students have done (Pakaya & Mursalin, 2019). The use of e-modules that integrate these steps will encourage students to think more critically in evaluating solutions to physics problems (Hidayat et al., 2023; Nazifah & Asrizal, 2022; Nurkhasanah & Rohaeti, 2024). Creative thinking is also a major focus with data showing that 54% of students were able to provide clear ideas, 53% had original ideas, and 54% were able to think uniquely. However, collecting data information in solving problems is still quite low at 45%. The syntax of Generate Hypothesis and Design Experiment in open inquiry e-modules can motivate students to generate innovative ideas and collect data systematically to solve complex physics challenges (Darmawan et al., 2020).

In addition, students' communication skills showed excellence, with 70% able to listen actively, 64% using appropriate communication, 52% applying formal language styles, and 67% utilizing formal body language. Through the Communicate Findings syntax, the e-module can facilitate students to convey their experimental results with formal and professional language, and improve active listening skills during discussions (Winarni et al., 2018). With the open inquiry approach, students not only understand physics material but also build essential 21st century skills (Ramdani et al., 2019). Students have not used e-modules and 77% need e-modules that can guide students in 21st century skills related to physics material. 80% of students want electronic-based teaching materials that can learn independently.

The solution to these problems is the use of electronic-based teaching materials (e-modules) (Doyan et al., 2020; Nazifah & Asrizal, 2022) and learning models that meet the needs of students integrated with 21st century skills (Nurmayanti et al., 2015; Nazifah & Asrizal, 2022). Learning physics requires teaching materials that support in-depth concept understanding through active student exploration (Putri et al., 2019). One relevant solution is the development of electronic modules (e-modules) based on contextual and innovative learning approaches, such as the Open Inquiry model. Open Inquiry-based physics e-modules allow students to be directly involved in the learning process by following systematic syntaxes, namely identifying problems, formulating hypotheses, designing and conducting experiments, analyzing data, and concluding results independently (Kuhlthau et al., 2007).

Based on the study, the open inquiry-based learning model is proven to be effective because it can increase student interaction, provide exploration opportunities, and encourage their curiosity in learning (Darmawan et al., 2020). This approach can be optimized if integrated in an open inquiry-based e-module. The open inquiry approach gives students the freedom to design and conduct their own experiments, analyze data, and draw conclusions. The syntax of open inquiry, such as problem identification, experiment design, data collection, analysis, and evaluation, are aligned with the 21st century skills of critical thinking, communication, collaboration, and creativity (4C) (Muniroh et al., 2023; Nazifah & Asrizal, 2022; Papilaya & Tuapattinaya, 2022; Tahya et al., 2022). After conducting preliminary research, the next step is to design a product in the form of a high school physics e-module on dynamic fluid material based on an open inquiry learning model integrated with 21st century learning. The following e-module product design will be developed as follows:

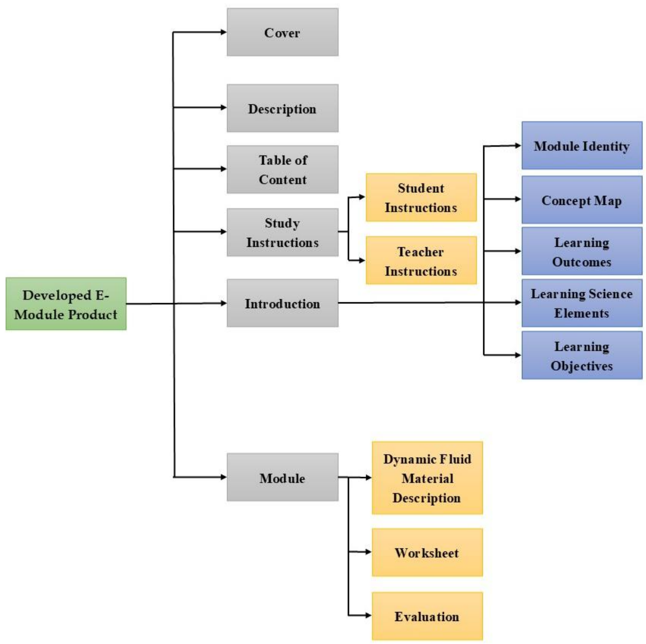

Figure 2. Product design of e-module to be developed

The development of e-modules based on open inquiry is expected to facilitate students to learn independently by utilizing technology. The advantage of this e-module lies in its flexibility, allowing students to learn independently while still integrating the Open Inquiry syntax (Yanti & Hamdu, 2021). The learning process begins by encouraging students to identify contextual problems (Identify), then ask scientific questions and hypotheses (Hypothesize). Students then design experiments (Plan), carry out experimental activities or observations (Experiment), analyze the results (Analyze), and finally make evidence-based conclusions (Conclude). Each of these syntaxes includes active learning elements that are relevant to the development of higher order thinking skills (HOTS) as demanded by Curriculum 2013 (Winarni et al., 2018).

In the context of physics learning at the high school level, Open Inquiry-based e-modules can be applied to materials that require in-depth exploration, such as fluid dynamics, waves, or electricity. This e-module can also facilitate students to be more independent, increase curiosity, and build strong science literacy skills through proving predictions and analyzing experimental data (Pakaya & Mursalin, 2019). Thus, the development of this e-module not only helps improve conceptual understanding, but also equips students with 21st century skills needed in the era of globalization. Integrating open inquiry syntax into physics e-modules not only helps students understand concepts, but also encourages them to apply physics in real life. This will help prepare students to face the challenges of the 21st century with relevant and in-depth skills.

Conclusion

This research illustrates the need for the development of e-module-based digital teaching materials in physics learning, especially on dynamic fluid material. The results show that most students face difficulties in understanding physics, especially on abstract concepts, and require technology-based teaching materials that are interactive and support independent learning. E-modules that integrate text, images, videos and animations are considered relevant to improve 21st century skills such as critical thinking, creativity, collaboration and communication. Therefore, this study suggests the development of e-modules based on an open inquiry learning model that emphasizes scientific investigation and active exploration to improve students' conceptual understanding and readiness. Steps that can be taken include conducting a survey to identify students' specific needs, developing an e-module prototype which is then tested, and providing training for teachers on the use of e-modules. The implication of this research is the development of e-modules that suit students' needs and the improvement of 21st century skills, which in turn can provide valuable insights for educators and curriculum developers in designing relevant and interesting teaching materials.

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