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STEM-BASED E-MODULES: THE KEY TO UNLOCKING STUDENT CREATIVITY IN THE DIGITAL AGE

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Abstract :
This research is classified as qualitative descriptive research. This study aims to assess the need for the use of E-Modules as a tool in high school physics subjects. This research uses a qualitative descriptive approach. The research survey questionnaire as an instrument. The questionnaire was distributed through a google form link, which was then filled in online by 1st and 3rd semester students who had studied physics subjects especially the subject of alternating current electricity. This research focuses on high school students class XII. The research involved 54 student respondents. The results showed that all respondents or 100% of students stated that they really need STEM-based learning to be used as a learning resource. Based on this research, there is a need for a learning E-Module as a learning media. This preliminary research will be developed into further research to create a STEM-based learning E-Module to train creative thinking skills on direct current electricity material.

Keywords: E-Modules, Creative thinking skills, STEM.

INTRODUCTION

Information technology and science are the most advanced fields as we progress towards the fourth industrial revolution. Thanks to advances in science and technology, we must always be ready to learn new skills, solve problems and be creative (Sury et al., 2022). The development of information and communication technology has brought significant changes in various aspects of life, including in education. One of the emerging learning innovations is the use of e-modules or electronic modules as digital teaching materials. The aim is to bring STEM closer to schools and develop critical thinking among students (Lupión-cobos et al., 2023). E-modules offer greater flexibility and interactivity than conventional printed modules. It requires new and widespread collaboration, diversity and dedication to change (Marlina, Wiyono, et al., 2024). Education is part of self-improvement activities and can improve the welfare of human life. Education is expected to produce qualified and skilled human resources. Learning in the 21st century demands change (Yuliana et al., 2023).

Physics learning must be supported by adequate resources. The digital era demands that educational materials can be accessed easily online and offline (Devi Permata Sari et al., 2023).

Therefore, the teaching resources used tend to be electronic learning materials. These educational resources include educational materials and electronic textbooks. Teachers must also have skills in presenting and preparing educational materials. Learning materials are not only in the form of modules or printed books, but can also be in other formats. (Hasih Nurhayati & Markos Siahaan, 2024) stated that there are three main types of educational materials, the first is audio, the second is visual, and the third is audio-visual. Therefore, the utilization of digital educational materials is a choice of educational materials that are in line with current developments. The unit is important for presenting materials created by subject teachers, taking into account the guidelines in a logical order and distributing them to students. Reaserch by (Saefullah et al., 2021) E-modules are independent, practical, interactive and flexible learning resources that can be used anytime and anywhere. Online modules are a solution in this era of disruption, where there is almost no distance and time in the learning process. The use of electronic modules is more effective than the printed version. Reaserch by (Ilmi et al., 2023)This is because electronic modules are equipped with images, videos and animations that help students understand the learning material. The current goal of preparing STEM teachers is to increase the number and quality of STEM teachers to help more students develop 21st century skills in critical and creative thinking and working collaboratively (Birney & Mcnamara, 2019). Science, Technology, Engineering and Mathematics (STEM) is considered as one of the educational alternatives that can build a generation to answer the challenges of the 21st century. The application of science, technology, engineering and mathematics (STEM) based learning is appropriate especially to meet the needs of skill acquisition that is growing in the 21st century (Hidayah et al., 2022).

On the other hand, the STEM (Science, Technology, Engineering, and Mathematics) learning approach is receiving increasing attention for its ability to integrate various disciplines and enhance students' 21st century skills (Pınar Çavaş , Ahmet Kara , Şengül S. Anagün, n.d.) in Pryor and Kang (2013) also support similar views and state that through STEM education, students can develop relationship-building skills that will enable them to apply their skills. Knowledge of the new situation of Education for Sustainable Development (ESD) has a big role in facing the challenges of globalization in the 21st century (Adi Apriadi Adiansha et al., 2020) in (Nazhifah et al., 2023). One of the crucial skills that need to be developed is creative thinking, which enables students to generate innovative ideas and unique solutions to problems (Azzahra et al., 2022).

However, the use of STEM-based e-modules to train students' creative thinking skills is still not optimal. The main purpose of implementing the STEM approach is to teach students to think critically and creatively in solving problems (Fadillah, 2024). This is due to various factors, including a lack of understanding of the specific needs of students and teachers in using the e-modules (Cahyani et al., 2020). The world is facing Industry 4.0 which requires a generation that is knowledgeable and able to face the challenges of new, more complex technologies (Aimi et al., 2020). Therefore, a comprehensive needs analysis is needed to identify important aspects in the development and implementation of effective STEM-based e-modules. Thinking skills or known as HOTS are very important to train students to be able to develop their abilities in problem solving (Marlina, Maisa, et al., 2024) The STEM approach can invite students to learn interdisciplinarily and contextually, integrating natural science, technology, engineering, and mathematics in problem solving (Hasan et al., 2024).

This needs analysis will help educators and teaching material developers to design e-modules that are not only in accordance with STEM principles, but also able to stimulate and develop students' creative thinking skills (Sihombing et al., 2021). A needs analysis is conducted to identify module needs before they are developed and evaluated at a later stage (Farihah et al., 2024). Learning using STEM-based e-modules can train students in applying the knowledge learned at school to the phenomena of everyday life, so as to improve their learning achievement (Ilmi et al., 2023). They found that inquiry activities provide independent learning opportunities to help students apply what they have learned in real life. Therefore, creativity should be instilled among students, for example, creativity in energy generation and management of energy resources (Othman, 2022). Thus, it is expected that the use of STEM-based e-modules can make a significant contribution in improving the quality of learning and preparing students to face challenges in the digital era (Azhary & Wiyono, 2020). And in line with research conducted by (Wiyono et al., 2024) The results indicated a notable enhancement in the teachers' test scores (N-gain of 0.79), and 82% of the participants found the training beneficial for their skills in

developing STEM learning tools, with an emphasis on fostering ongoing collaboration for the continued use and development of these educational resources (Novi , Rusmansyah, 2024).

In line with research conducted by (Nanda Putri Pertiwi, 2024) that the creation of a web-based E-module designed to improve critical thinking skills among high school students in Indonesia through a STEM approach and a Problem-Based Contextual Learning model, which incorporates virtual experiments. The study involved 216 students from three schools and reported high validation scores for the E-module, indicating its effectiveness in improving critical thinking skills, with an N-Gain score of 0.70, surpassing traditional media methods. Research by (Rohman & Husna, 2021) this important research will integrate the STEM approach with e-modules, creating a new framework that can be used to enhance student creativity. With the development of technology, this research will provide innovative solutions to utilize e-modules to encourage student creativity in the digital era. The results of this research can be a reference for educators and curriculum developers in designing learning materials that are more interactive, interesting, and encourage creativity.

This research is in line with the needs of 21st century education that emphasizes the development of creative, critical, and collaborative skills through the use of technology. The novelty in this research will produce a product in the form of STEM alternating current material e-modules in the context of Palembang light rail transit (LRT) to train creative high school students grade XII which later this product not only makes a theoretical contribution by filling gaps in existing literature, but also offers practical solutions that are relevant to the needs of education in the digital era. By integrating the STEM approach, digital technology, and a focus on creativity, this research is expected to be a breakthrough in improving the quality of learning and preparing students to face future challenges. Research conducted by (Oschepkov et al., 2022) Key findings revealed a notable correlation between intrinsic motivation and the transition from normative to creative thinking, alongside the model's effectiveness in improving students' engineering and creative thinking skills, with implications for future research and teaching methodologies in STEM education. Research conducted by (Arifin & Siew, 2023) significant improvements in ECT scores for students who engaged with the module compared to a control group.

RESEARCH METHOD

Research Design

This study uses a development research approach to create and test STEM-based e-modules in physics learning. The research design includes needs analysis, e-modules development, pilot testing, and evaluation of the effectiveness of e-modules in improving students' material understanding and collaboration skills. The research method involves a combination of qualitative (needs analysis and teacher/student responses) and quantitative (training creative thinking skills) approaches (Fadillah, 2024).

Research Target/Subject

The subject of this research is high school students who study physics, especially alternating current electricity. Respondents of this research are students who have studied alternating current electricity material. Focusing on student needs for STEM-based e-modules to understand the material better, as well as teacher needs in creating innovative learning media (Mulyani, 2019).

Research Procedure

Needs Analysis: Identifying the needs of students and teachers related to the use of e-modules in physics learning. Analyzing challenges faced by teachers, such as limited ability to utilize technology (Mahyuddin et al., 2025). E-Modules Development: Designing STEM-based e-modules that are interactive and tailored to student needs. Integrating physics content with STEM approach to create an innovative learning environment.

Trial and Implementation: Conducting e-modules trial in physics class to see its effectiveness in improving students' material understanding and collaboration skills. Collect responses from students and teachers through questionnaires, observations and interviews.

Evaluation and Revision: Analyzing the trial results to evaluate the advantages and disadvantages of e-modules. Make revisions based on feedback from students and teachers to improve the quality of e-modules (Gunawan et al., 2025).

Research methode

This research uses mixed methods, combining qualitative and quantitative approaches to collect comprehensive data (Setiawan, 2023). First, relevant scholarly articles from various reliable sources, such as international journals, conference proceedings, and textbooks, were collected to obtain theoretical foundations and recent findings related to the research topic. Some of the international journals referenced include a recent study by (Zhang, Y., Li, X., & Wang, 2023) on technology integration in physics learning and research by (Almeida, R., Santos, P., & Costa, 2024) which examined the effectiveness of digital media in increasing student engagement. The articles were systematically analyzed using literature review techniques to identify research gaps and develop a conceptual framework. Next, in-depth interviews were conducted with physics teachers as key respondents (Lesmono et al., 2022). The interviews aimed to explore teachers' practical perspectives, challenges and needs in implementing technology-based learning media. The interview questions were open-ended to allow teachers to convey their experiences and views in detail. In addition, this study also used a Google Form-based questionnaire distributed to students and teachers. This questionnaire contains closed questions and Likert scale to measure the response, perception, and acceptance level of the developed learning media. The use of Google Form facilitates the data collection process efficiently and enables real-time data analysis. The study by (Kumar, S., & Lee, 2025) also supports the use of digital questionnaires as an effective tool for collecting data in educational research. The combination of these three methods ensures that the data obtained is holistic, valid and reliable, thus supporting the overall research findings.

RESULTS AND DISCUSSION

Research on student needs for learning media in the form of e-modules begins with the use of electronic devices in learning. The results of the use of electronic devices for learning obtained based on research can be seen in Table 1. Based on the table, it was found that 30 students out of the total number of student respondents with a percentage of 55.6% chose cellphones as the most frequently used electronic device. then the time using the cellphone in a day, the results showed that 26 students with a percentage of 48.1% chose the time using the cellphone was for 2-5 hours. Then, 25 students with a percentage of 46.3% chose the time using a cellphone was 1-2 hours. And, 3 students with a percentage of 5.6% chose the time using a cellphone to reach more than 5 hours.

Table 1. Use of electronic devices (cellphones) in a day

Number	Information	Indicator	Amount	Persentase
1	Length of time using mobile device in a day	1-2 hours	25	46,3%
		2-5 hours	26	48,1%
		more than 5 hours	3	5,6%

Furthermore, analyze the results of the needs of the use of learning e-modules by high school students. Based on the results of the analysis of the use of learning e-modules by high school students can be seen in Table 2, the results obtained include the opinion that students often use applications, namely social media 34 students from the total respondents with a percentage of 63%, then 6 respondents play games more often, namely 11.1%, and the remaining 25.9% are used to access learning applications. There are 85.2% as many as 46 respondents have implemented the independent curriculum, the rest have not been implemented by 14.8% or 8 respondents only.

Tabel 2. Use of Learning e-modules

Number	Indicator	Description	Amount	Percentage
1	Aplikasi yang sering diakses	Games	6	11,1%

		Learning App	14	25,9%
		Social Media	34	63%
2	Have learned to use the independent curriculum	Already	46	85,2%
		Not yet	8	14,8%

Next is to analyze the needs analysis questionnaire on the components most listed in the learning e-module to make it easier for students to understand the material. The results showed that students chose as many as 8 respondents with a percentage of 14.8%, respondents chose that there were video links and relevant websites as many as 24 with a percentage of 44.4%, then the respondents chose that there were many questions and communicative language as many as 31 people with a percentage of 57.4%, besides that according to the respondents in Associated with activities or daily events as many as 36 students with 66.7%, and respondents also chose e-modules that included pictures as many as 38 people with a percentage of 70.4%.

Table 3. Components Included in the Learning e-module

Number	Information	Amount	Percentage
1	Create multiple texts	8	14,8%
2	There are relevant video and website links	24	44,4%
3	There are many questions and communicative language	31	57,4%
4	Linked to everyday activities or events	36	66,7%
5	Picture included	38	70,4%

The next analysis is the results of the learning e-module requirements. Based on the results of the analysis in Table 3, it was developed again with the question of whether you agree with learning that can be done anytime and anywhere, where all respondents chose to agree with a percentage of 100%. On the other hand, further to the question Do you think it is necessary to develop a STEM-based physics E-MODUL to be used as another learning resource, all respondents answered yes with a percentage of 100%.

Tabel 4. Use of e-modules

No	Information	Percentage
1	Do you agree with learning that can be done anytime and anywhere?	100%
2	Do you think it is necessary to develop a STEM-based physics E-MODULE to be used as another learning resource?	100%

The challenges in developing e-modules are that many teachers face difficulties in making learning media due to limited technological capabilities and the need for training and support for teachers to improve competence in developing e-modules. Positive responses to e-modules where the results of student questionnaires responded positively to the use of STEM-based e-modules in physics learning. And e-modules are considered effective in creating an innovative learning environment and tailored to the individual needs of students (Santosa, Alif Satria Egar, Gede Saindra Santyadiputra, 2025).

The contribution of e-modules to creative skills in the results of the research questionnaire shows that e-modules make a significant contribution in training students' creative skills (Oktavia et al., 2024). E-modules also facilitate interaction and cooperation between students through project-based activities and discussions. Recommendations for further research need to be carried out further research to test the effectiveness of e-modules in a broader context, including other subjects and different levels of education as well as the development of more user-friendly e-modules to facilitate teachers in creating and implementing learning (Herak & Lamanepa, 2024).

CONCLUSION

Based on the research described in this article related to the use of STEM-based learning e-modules, it can be concluded that learning media is needed to support the learning process. E-learning module is one of the media that can help the learning process for students at school. Physics learning really needs media or tools to facilitate understanding of the material, especially material related to natural phenomena which aims to create an innovative learning environment that can be tailored to the needs of each student. There are needs from students related to STEM-based learning e-modules so that students understand the material well. Then there is a need in making e-modules to make it easier for teachers to make learning media. Based on the research results, respondents have responded positively to STEM-based learning videos in physics learning. However, the development of this learning e-module is low, this is due to the fact that many teachers still face challenges and difficulties in the process of making learning media, one of which is the limited ability to utilize technology.

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