



STEM-Based E-Modules to Improve Students' Critical Thinking in Economic Learning

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ABSTRAK

Kemajuan ilmu pengetahuan dan teknologi mengalami kemajuan pesat di abad ke-21, khususnya di bidang pendidikan. Siswa perlu dipersiapkan menghadapi kemajuan tersebut dengan memiliki keterampilan teknis dan kemampuan berpikir kritis yang diperlukan untuk mendukung pemanfaatan teknologi. Ketika siswa tidak mampu merumuskan pertanyaan kritis, maka siswa hanya mampu mengajukan pertanyaan dasar saja. Hal ini menggarisbawahi pentingnya keterampilan berpikir kritis dalam pengajaran ekonomi. Penelitian ini bertujuan untuk menguji kelayakan e-modul berbasis STEM dan mengevaluasi efektivitasnya. Penelitian ini termasuk dalam klasifikasi penelitian dan pengembangan (R&D) yang menggunakan modifikasi kerangka Thiagarajan. Metode analisis data yang diterapkan dalam penelitian ini meliputi analisis deskriptif mengenai kelayakan modul. Pengujian N-gain digunakan sebagai metode untuk mengevaluasi efektivitas produk. Temuan penelitian menunjukkan bahwa: (1) e-modul berbasis STEM yang dibuat memenuhi standar sangat baik dari segi bahasa, isi, dan penyajian; dan (2) terdapat peningkatan skor N-gain yang tergolong tinggi dalam menilai kemampuan berpikir kritis siswa. Hasil ini mendukung anggapan bahwa e-modul berbasis STEM yang dibuat dapat menjadi media pembelajaran Pengantar Ilmu Ekonomi yang efektif pada domain pendidikan ekonomi.

ABSTRACT

The scientific and technological advancements have rapidly progressed in the 21st century, especially in the field of education. Students need to be prepared for these advancements by possessing technical skills and critical thinking abilities necessary to support technology utilization. When students are unable to formulate critical questions, they are only capable of asking basic questions. This underscores the importance of critical thinking skills in teaching economics. This research aims to examine the feasibility of STEM-based e-modules and evaluate their effectiveness. This study falls under the classification of research and development (R&D) employing modifications from the Thiagarajan framework. The data analysis method applied in this study includes descriptive analysis concerning the module's feasibility. N-gain testing is utilized as a method to evaluate product effectiveness. The research findings indicate that: (1) the STEM-based e-modules created meet standards excellently in terms of language, content, and presentation; and (2) there is a noteworthy increase in the N-gain score, categorized as high in evaluating students' critical thinking abilities. These results support the notion that the created STEM-based e-modules can serve as an effective learning medium for Introduction to Economics within the economics education domain.

1. INTRODUCTION

Education today must combine reading and writing skills with technological abilities, knowledge, skills, talents and attitudes (Irawati, E. et al., 2022; Nurcholis & Istiningsih, 2021). Every individual is expected to develop critical thinking skills, have broad knowledge, and master media literacy, information, digital, and information and communication technology to overcome the learning process in the 21st century era. Partnership for 21st Century Learning (P21) has developed a 21st century learning framework that emphasizes the need for students to have skills for everyday life and career, skills in learning and innovation, and also proficiency in technology, media, and information (Chairunnisak, 2020; child & shaw,

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2016). This framework details the skills, knowledge, and expertise students need to be successful in their personal and professional lives.

Students' ability to analyze, evaluate, and draw conclusions from their learning is enhanced by critical thinking skills, which are considered vital in the classroom environment. Critical thinking involves applying these skills to draw logical conclusions about what to believe or do. In the 21st century, finding new solutions to challenges requires research (Pertiwi, TP et al., 2024; Setiarsih, 2017). Critical thinking skills are the ability to observe, analyze, and evaluate situations or information carefully and rationally. According to previous research, this is considered an important competency in modern education and today's life (Elfina & Sylvia, 2020; Herlina et al., 2022). This ability enables a person to make better decisions, solve problems more effectively, and develop a deeper understanding of the situation or information provided (Agnafia, 2019; Irawan & Kencanawaty, 2017). The fundamental of critical thinking is the ability to think clearly. This includes the ability to organize and evaluate information in a logical and objective manner. Individuals who are able to think critically have the ability to see problems from multiple perspectives, evaluate arguments carefully, and understand the implications of decisions made (Novikasari, 2009; Septiana & Kurniawan, 2018).

Critical thinking skills will give students the ability to successfully handle problems. The process of developing a person's critical thinking skills will occur over time when they face new challenges or unsolved difficulties. This phenomenon occurs when individuals obtain new information which is then stored in their memory, allowing for reorganization or the formation of relationships between various pieces of information to achieve certain goals or find desired solutions (Fadil, K. et al., 2024; Rizki Kurniati et al., 2024). Therefore, the importance of critical thinking becomes very necessary to ensure that the information obtained has the appropriate validity when faced with various choices (Agnafia, 2019; Sulianto, 2008).

Student-centered learning, where students are given the freedom to direct their own learning process, is emphasized in the Independent Curriculum (Astini, 2022; Suhartono, 2021). Students who have critical thinking skills will be encouraged to challenge assumptions, consider multiple perspectives, and reach logical conclusions. Students are also encouraged to participate in class discussions and collaborate with classmates under the Merdeka Curriculum. During discussions, students can debate, ask questions, and listen to other people's perspectives. Students who collaborate with classmates can also see other perspectives and get feedback.

However, there are still some students who show deficiencies in critical thinking skills. Some factors that cause a lack of critical thinking skills include limited opportunities to practice these skills, lack of guidance, and lack of time management. There are many reasons that result in low critical thinking skills in students, one of which is the tendency of students to memorize facts and formulas rather than understand fundamental concepts (Agusta & Sadijah, 2021; Zahra et al., 2018). This is in line with initial research which explains that the low level of student response and their tendency to prefer memorizing rather than understanding the concept are the causes.

Observations conducted at SMA Negeri 1 Tejakula showed low critical thinking skills of class X IPS 1 students in the subject of economics. This can be seen from the learning process in the classroom. Instead of understanding the concept, many students tend to memorize the material and show a lack of responsiveness to the learning process. Few students are able to ask direct questions during learning sessions because they are unable to develop critical questions and can only ask simple questions. When given the opportunity to debate, students are unable to evaluate arguments. Therefore, it is very important to develop students' critical thinking skills in economics learning, especially when integrating this knowledge into the Merdeka Curriculum.

Independent Curriculum is a teaching method that gives students the autonomy to direct their own education, including economics instruction. Using appropriate teaching strategies is essential to support the development of critical thinking skills in economics in students within the Independent Curriculum Framework (Fitriyah, 2020; M. Putra et al., 2018). One of these strategies is the integration of STEM (science, technology, engineering, and mathematics). Through the implementation of the Independent Curriculum with a STEM approach in teaching economics, students will learn how to collect, evaluate, and understand economic data (Ardianti & Amalia, 2022; Sabriadi, 2021).

The novelty of this study highlights the urgency of developing students' critical thinking skills, especially in the context of economic learning, in the 21st century education era. With a focus on the integration of STEM in the Merdeka Curriculum, this study aims to evaluate the effectiveness of STEM-based e-modules in improving students' critical thinking skills at SMA Negeri 1 Tejakula. The evaluation method includes an assessment of the feasibility, usability, and effectiveness of the e-module, as well as analysis of student learning outcome data before and after the implementation of the e-module. This shows a contemporary effort in addressing the challenge of the lack of critical thinking skills among students, with an innovative approach to improving learning in the modern era. This study aims to conduct a

comprehensive evaluation of e-modules based on Science, Technology, Engineering, and Mathematics (STEM) in the context of education at SMA Negeri 1 Tejakula.

2. METHOD

This study adapts the Research and Development (R&D) methodology by referring to Thiagarajan's framework to develop and evaluate STEM-based e-modules in the context of teaching economics at SMA Negeri 1 Tejakula (Rohmah & Tegeh, 2022). The subject group consisted of tenth grade students, where ten students from class IPS 1 became the objects of the readability test, while one class with 60 students from class X participated in the effectiveness test.

Qualitative and quantitative approaches were used in data collection, with the use of tests to collect cognitive data related to the Introduction to Economics curriculum. The STEM e-module was assessed through validation to assess its applicability, and product feasibility evaluation was carried out by experts in the fields of material, language, and presentation. Two different types of questionnaires were used to collect data, one of which was to evaluate student responses to the STEM module that had been created.

This method holistically allows for a comprehensive evaluation of the development and implementation of e-modules, taking into account various aspects from validity, feasibility, to student responses, which form the basis for updating and improving the proposed learning approach. (Pratama & Sakti, 2020; Rando, 2017).

3. RESULT AND DISCUSSION

Result

SMAN 1 Tejakula is located in Tejakula Village, Tejakula District, Buleleng Regency, Bali Province. It is approximately 35 km from the district center and approximately 86 km from the provincial center. Its location provides a very supportive environment for intellectual development. In SMAN 1 Tejakula, there are highly competent human resources, adequate facilities, and a social and cultural atmosphere rich in local Balinese values that are continuously applied. This study began by identifying the potential that exists in SMA Negeri 1 Tejakula. The teaching process of Economics has not fully utilized and optimized the use of instructional media in teaching and learning activities, as is known from the characteristics found. The teaching strategies used in Economics are conventional; worksheets and textbooks are the only sources used (LKS). In addition, teachers do not create these learning resources themselves, and this does not significantly increase student interest in the learning process.

The percentage-based descriptive analysis of the results of the expert assessment will provide a more detailed picture of the extent to which the e-module meets the criteria or standards that have been set. This will help in determining the level of e-module eligibility and ensuring that the e-module meets the requirements needed to improve students' critical thinking skills at SMA Negeri 1 Tejakula as shown in Table 1.

Table 1. The Recapitulation of the Feasibility Assessment of STEM-based E-modules by Experts

Expert	Percentage	Criteria
Based on Content	92.4%	Very Worth It
Based on Presentation	88.9%	Very Worth It
Based on Language	89.2%	Very Worth It

Based on Table 1, the analysis provides an overview of the evaluation conducted by four experts on STEM-based e-modules. The evaluation was conducted on three main aspects: content suitability (92.4%), presentation (88.9%), and language (89.2%). High percentages in each aspect indicate a very good level of suitability of the evaluated e-modules. The results of the evaluation by the experts are the basis for making improvements to the components of the e-module before the trial phase is carried out on students at school. This process is an important part of e-module development because input from experts helps in improving and perfecting the content, presentation, and language of the e-module to better suit the needs and obtain better responses from students.

After making revisions based on input from experts, the e-module was then tested for readability on ten students. The results of the readability test showed a success rate of 85%, which is also included in the very good criteria. This confirms that the revised e-module received a positive response from students in terms of the readability of the material presented. In addition, interviews with students also confirmed that the STEM-based e-module provided significant assistance in understanding introductory economics material. This indicates that the e-module is not only appropriate in terms of technical and readability, but

also provides direct benefits to students in understanding and learning the subject matter. Overall, the results of the evaluation by experts and the trial with students as well as responses from student interviews provide strong evidence that the STEM-based e-module has been successful in being refined and providing significant benefits in the learning process at school.

A test is used to determine how well the STEM-based online module affects students' critical thinking skills. The N-gain formula can be used to determine the efficacy of the product. The purpose of using N-gain is to assess how much students' critical thinking skills increase both before and after the treatment (pretest and posttest). The difference between the pretest and posttest scores is measured using N-gain. Table 2 displays the pretest-posttest scores as well as the N-gain value.

Table 2. The N-gain Score Results

Data	N-gain test	
	Class X2	Class X5
Average pre-test score	50.33	53.67
Mean post-test score	79	82.67
N-Gain	0.57	0.63
Category	Currently	Currently

Table 2 displays the N-gain value for each of the sixty students. After giving the pre-test and post-test to both classes, the N-gain obtained, which meets the moderate criteria, is 0.60. Based on this data, it can be seen that after using the STEM-based economics e-module, the average score of students increased.

Discussion

The evaluation results from three experts, namely content feasibility experts, presentation feasibility experts, and language feasibility experts, showed percentages of 92.4%, 88.9%, and 89.2% respectively in assessing the feasibility of the STEM-based e-module. The four validators considered the product very practical, suggesting that this module can be useful in learning activities. The content, presentation, and language facilities of the STEM-based e-module showed a reasonable suitability for its use in an educational context. The application of the STEM method encourages students to be more motivated and actively involved in the learning process. This triggers more active participation in class discussions and improves critical thinking skills that have been taught.

Ensuring that students receive feedback that is relevant to their understanding of the subject matter is the goal of engaging them in STEM education. The goal of this feedback is to help students correct any misconceptions they may have by strengthening their understanding of the topics they have learned and how they relate to each other (Izzah & Mulyana, 2021; Saptono et al., 2017).

The study also revealed the relationship between learning outcomes and the learning activities that students participate in. Only when students are truly involved in learning activities can high learning outcomes be achieved (Khoiroh, 2018; Nurmahni Harahap, 2014). Student learning outcomes and motivation to learn can be improved by using mobile phones to access the latest educational resources. In addition, these e-modules can be accessed via students' laptops and mobile phones. Since these e-modules can be accessed from anywhere and at any time, are supported by adequate resources, and do not cause difficulties for students, their use attracts students' attention to the learning process (Maharcika et al., 2021; Qodr et al., 2021).

In addition, even when they are in different places from their students, teachers find that conducting teaching activities becomes easier. In addition to providing useful and engaging learning assessments for students, e-modules serve as teaching tools that include materials and methodologies. Diagrams showing the relationship between STEM in each subject area are included in the e-modules presented. This can help students understand basic economic concepts more easily by using the STEM approach. The STEM approach has several advantages that help students become more proficient in solving problems, being creative and innovative, thinking independently, using logic to rationalize, and having technological literacy (Istuningsih et al., 2018; Stohlmann et al., 2012).

Ten (10) randomly selected students from class X4 were given a questionnaire regarding their readability test results. Two (2) was the lowest score, while four (4) was the best. The students were asked to provide feedback regarding their readability in individual trials, which included sentence length, grammar, and vocabulary issues. Sentence length affects students' memory, and readability elements also affect the extent to which the material is understood by the reader (KWB Putra et al., 2017; Winaya et al., 2016). The average result of the small-scale experiment was 85%, which is included in the very good criteria. Students provided feedback indicating that although the e-module was comprehensive and well-written, they still lacked experience in navigating it.

Before starting the Introduction to Economics lesson, a pretest was conducted at the initial meeting. In addition, the use of STEM-based e-modules has never been implemented before in the student learning experience. Teachers have the ability to maintain the continuity of learning concepts between students and teachers by utilizing students' prior knowledge as a starting point for introducing concepts to be learned (Haeruman et al., 2017; Noviyanti et al., 2014). The purpose of the pretest is to assess students' prior knowledge and to evaluate how well they understand the material. Students' prior knowledge has a significant impact on how they understand the new topic being presented.

The observed improvement in students' critical thinking skills after using e-modules in the teaching-learning process is reflected in the results of the post-test. This shows that STEM-based e-modules have had a positive impact on students' ability to think critically after they use the materials presented through the e-modules (Kimianti & Prasetyo, 2019; Laili et al., 2019). This study states that the use of e-modules provides greater opportunities for students to learn independently, adapt to the material, and apply knowledge practically. Thus, it allows students to improve their scientific literacy, helping them to better face everyday challenges and global issues. The increase in scores between the pre-test and post-test indicates significant progress after the implementation of STEM-based e-modules (Aprilliyah, 2014; Nurhayati et al., 2021). This illustrates that the e-module is successful in improving students' understanding and critical thinking skills in understanding and dealing with the STEM subject matter being taught.

The implications of this study indicate that the use of STEM-based e-modules can improve the quality of learning, especially in terms of student engagement and the development of critical thinking skills. This indicates that technology-based e-modules can be an effective solution in facing the challenges of modern education, as well as supporting the integration of technology in the learning process. With e-modules that can be accessed through various devices such as mobile phones and laptops, students have greater flexibility and accessibility to learn from anywhere and anytime, which can increase their learning motivation. In addition, the results of this study can be used as a basis for the development of a more comprehensive STEM-based curriculum that is relevant to the needs of today's students, helping to develop their problem-solving skills, creativity, and innovation.

This study also has several limitations. One is the relatively small sample size, which is only ten students from one class, so the results may not be generalizable to a wider student population. In addition, this study was conducted in a limited period of time, so it has not been able to evaluate the long-term impact of the use of STEM-based e-modules on student learning outcomes. Variability in teaching by teachers, who may have different skills and experiences in using technology, can also affect the consistency of the results of this study. This study has several advantages. The assessment methods used in this study are quite comprehensive including pretest, posttest, readability questionnaire, and expert evaluation so as to provide a more in-depth picture of the effectiveness of STEM-based e-modules.

4. CONCLUSION

Based on this study, it can be concluded that the use of STEM-based e-modules in high schools significantly improves the quality of learning, especially in increasing student engagement and their critical thinking skills. The e-modules that have gone through the evaluation and revision process have proven to be very feasible to use, with high expert assessment results and good readability tests. Although this study has limitations in terms of sample size and duration, the results provide strong evidence of the benefits of STEM-based e-modules in supporting more interactive and effective learning. Therefore, these e-modules can be valuable tools in developing more modern and relevant curricula, supporting the integration of technology in education, and helping students develop critical 21st century skills.

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