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Development and Validation of Learning Strategy for Creative Thinking Skills Empowerment: STEM-Based E-Modules

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Abstract: The feasibility on the learning tools is crucial because it ensures the validity of the data and information obtained. This study aims to describe the validity and reliability of STEM-based learning e-modules to train creative thinking skills, describe the effectiveness of STEM- based learning e-modules creative thinking skills, and describe student responses after learning using STEM-based e-modules. This research is Research and Development (R&D). The development modul used is the 4-D device development model. There are consist of the define, design, develop, and disseminate stage. The data were analysed descriptively quantitatively. The target of the e-modules trial was 11 student of class X IPA SMAM 4 Sidayu, Gresik, Indonesia. The data collecting techniques using validation techniques, tests, and questionnaires. The results were the validity of STEM-based e-modules to train creative thinking skills obtained 73.25% which is included in the valid category and can be tested on students. The data were analysed descriptively throught T-test and N-Gain. From the research results, it was concluded that the e-modules media is declared valid, STEM based e-modules are effective enough to train creative thinking skills, and student responses to e-modules are very good.

Keywords: Creative Thinking Skills; E-Modul; STEM; Student Response

Introduction

The education is a basic need for humans to build their knowledge so that it is expected to build self-potential and a mindset that aims to solve problems in their lives. Without education, a country will be left far behind with other countries. Therefore, education is of great concern to countries including Indonesia. Entering the 21st century, according to (Tadesse & Muluye, 2020), in facing very complex challenges, the national education system must developing human resources who can compete in the global era. Regarding the challenges on globalization, referring to the national education system, the National Education Standars Agency (BNSP) formulated 8 paradigms of national education in the 21st century, including education not only makes students have knowledge, but has scientific and technological insights, which are critical, logical, inventive, innovative and consistent, but also accompanied by adaptability (Kioupi & Voulvoulis, 2019).

The learning paradigms emphasizes on the development of higher-order thinking skills, namely critical thinking, creative thinking, communication, and collaboration skills. Creative thinking skills are crucial for investigating a problem, discovering and analyzing facts and data to solve issues. The integration of creative thinking in learning prepares students to become adept problem solvers. According with (Amran et al., 2019), creative thinking skills refer to an individual's ability to explore ways, strategies, ideas, or new concepts to find solutions to a given problem.

In line with (Postgraduate Student at Universitas Negeri Malang et al., 2021), creative thinking includes

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the ability to comprehend objects, test existing hypotheses, and communicate findings. (Torrance, 1972), creative thinking has aspects of fluency, flexibility, originality, and elaboration which are the main cognitive processes used to define and asses creativity. The research by (Listiana & Bahri, 2019), creative thinking is important to develop because it can train learners to develop their mindset. Creative thinking needs to be honed so that learners are fluent and flexible in thinking, able to analyse a problem from a wide range of perspectives, and able to generate many ideas. Finding and analyzing facts and data to investigate problems and solve problems requires creative thinking skills. The interconnectedness of creative thinking in learning prepares students to become reliable problem solvers

The learning of biology encompasses conceptual, factual, procedural, and metacognitive knowledge. The materials studied often require detailed explanations of processes and mechanisms, as well as phenomena and occurrences in nature, the human body, animals, and plants. Meanwhile, the teaching and learning concepts have predominantly been carried out through lectures and completing tasks in the form of various questions. This results in students being less trained to sharpen higher-order thinking processes, namely identifying, analyzing, seeking alternative solutions, and drawing conclusions in a given case.

The pre-research results through interviews and observations with biology teachers of the 10th-grade science class at SMAM 4 Sidayu indicate that student learning outcomes in biology are still classified as low to moderate. The teacher-centered approach still dominates the classroom, and most students have difficulty understanding the material due to the use of summarized workbook (LKS) content. Teachers have not adopted a specific teaching model, and instructional materials such as modules have not been utilized as student learning resources. The current teaching methods have not effectively stimulated higher-order thinking abilities. Additionally, students' proficiency in solving interdisciplinary problems remains inadequate. The teachers express a strong desire for the availability of modules or e-modules that can assist students in understanding the material, fostering active student engagement, and positively impacting learning outcomes.

To address the issues mentioned above, the development of instructional materials is essential. Learning with the use of instructional materials should not only be teacher-focused but also enable students to learn independently without a facilitator. (Rizki et al., 2021), suggests that good instructional materials can adapt to the learners' surrounding environment. Therefore, the development of instructional materials in the form of e-modules is expected to facilitate and assist students in understanding the material more effectively. E-moduls is an instructional material that utilizes technology, information, and communication. The e-module serves as a learning resource that presents content in multimedia formats such as videos, animations, simulations, and tests that allow for direct feedback. According to (Kossen & Ooi, 2021), learning with audio-visual elements, feedback, and engaging content can enhance the absorption of learning materials.

(Kelley & Knowles, 2016), several aspects of STEM are an important part of every implementation of the learning process. There are the steps required to implement each aspect of STEM; Steps one, the scientific aspect is the skill of applying scientific knowledge and processes to understand natural phenomena. Begins with a question a phenomenon, Scientific investigation in field or lab using a systematic approach. Steps two, Technology aspect, is the ability to operate a new technology that can be developed and proper application of the technology, name is technological literacy. Steps three, engineering aspect is the STEM approach to engineering design allows students to build upon their own experiences and provide opportunities to construct new science and math knowledge through design analysis and scientific investigation. Steps four, the technical aspect is a person's ability to manipulate something, especially engineering. Steps four, the mathematical aspect is the ability to analyze and communicate ideas, solve problems and interpret solutions mathematically. Mathematically proficient students explain the meaning of a problem and looks for solution entry points.

According to (Coman et al., 2020), e-modules are designed to be user-friendly for independent learning, equipped with instructional guidance for easy comprehension. The use of e-modules makes learning resources accessible anytime. Therefore, there is a need for innovation in developing e-modules that can enhance students' higher-order thinking skills by integrating the Science, Technology, Engineering, and Mathematics (STEM) approach. (Laksono et al., 2021), The STEM approach is capable of increasing students' interest and understanding in scientific technology while enhancing their ability to solve real-world problems. In line (Cahyani et al., 2020), in the learning process using STEM, various pieces of information can be formed through collaborative and creative problem-solving analysis, thereby equipping students with skills and creativity. Therefore, in this study, an E-module in biology based on STEM is developed as a learning medium to cultivate students' creative thinking abilities.

Many studies have been conducted to reveal adventages STEM approach. The construction of STEM Education-based e-modules is used as a reference for

meaningful learning to enhance critical and creative thinking skills (Aswirna et al., 2022); (Wulansari et al., 2023). Further research indicates that STEM-based e-modules can enhance scientific literacy because the STEM approach is more focused on real-life problems, grounded in four aspects: science, technology, engineering, and mathematics (Rasmi et al., 2023).

Method

This study was a Research and Development (R&D) that aimed to produce learning tools in the form of the lesson plan, evaluation sheets, and STEM-based E-Modules that are valid, practical, and effective in Biology material. This development research procedure referred to the 4-D model of development (Gorbi Irawan et al., 2018), which includes the stages of the 4-D development model consists of the stages of definition (define), design (design), development (develop), and dissemination (disseminate). In the Define stage, curriculum analysis, student analysis, concept analysis, task analysis, and learning objectives are carried out. In the Design stage, the development of STEM-based learning tools is done, including lesson plans, student worksheets, subject matter on Ecosystems, evaluation sheets, and the design of STEM-based e-modules.

In the Develop stage, content validity testing is conducted by 3 validators, a limited-scale trial is performed to determine the effectiveness of the STEM-based e-module, and practicality testing is conducted using questionnaires. In this study, the process is conducted only up to the development stage. The samples in this study only one class were 11 students in the 10th-grade Science class at SMAM 4 Sidayu, Gresik, Indonesia. The instruments used in this research were observation sheets, questionnaire sheets, validation assessment sheets, and sheets essay tests. The observation was carried out on 11 students as the population and samples of this research by using observation sheets. Observation sheets were used to find find out the learning difficulties experienced by students, and need analysis for learning biology. The questionnaire sheet was used for students' responses after learning using STEM-based e-modules. Validation assessment sheets were used to obtain product validity data according to three experts namely a media expert, a learning expert, and a practitioner.

The assessment sheet in the form of essays tests was used to obtain effectiveness tests data according to 21 students and one lecturers of biology. The test technique is used to measure the creative thinking skills of students' after applying STEM-based e-modules learning, involves aspects of fluency, flexibility, originality, and elaboration (Sukarso et al., 2022). All instruments were valid and reliable before use. The data were collected in the form of quantitative data, and analyzed descriptively, equipped with triangulation of methods and data sources. The analyzed data includes empirical validity data consisting validity and reliability, content validity data, effectiveness and practibilty product. Data from the validation sheet will be calculated using the formula:

$$\%Validity\ EModul = \frac{The\ total\ score\ in\ the\ review}{maximum\ score} x\ 100 \quad (1)$$

The subsequent calculation results determine its validity criteria, based on validity criteria presented in Table 1.

Table 1. Validity criteria

Score interval	Criteria
$81.26 < \bar{x}$ 100	very valid
$62.51 < \bar{x}$ 81.25	valid
$43.76 < \bar{x}$ 62.50	less valid
$25.00 < \bar{x}$ 43.75	not valid

(Source: (Ab Hamid et al., 2017))

The empirical validity data is calculated from test results obtained from pretest and posttest. The participants' creative thinking abilities are analyzed through the answers they have provided. The data obtained is further analyzed by assigning codes to the answers and scoring the answers based on the assessment rubric. Subsequently, the total test scores are calculated for each indicator of creative thinking, and the percentage score for creative thinking ability is determined for each emerging aspect. The percentage is calculated using the following formula:

$$Score = \frac{Creative\ Score\ x\ Question\ Weight}{Maximum\ score} x\ 100 \quad (2)$$

The data will then be analysed with the T-test and N-Gain test. The N-gain value is calculated using the following formula.

$$N - gain = \frac{Spost - Spre}{Smaks - Spre} x\ 100\% \quad (3)$$

Table 2. The level of N-gain percentage will be determined based on the criteria in Table 2

N-gain Score (%)	Category
N > 70	High
30 ≤ N ≤ 70	Medium
N < 30	Low

(Source: (Damayanti & Kuswanto, 2020)

The questionnaire is used to determine students' responses after the implementation of STEM-based e-learning modules. The questionnaire results are

analyzed by calculating the percentage for each statement for each answer choice, using the following formula:

$$P = \frac{f}{n} x\ 100 \quad (4)$$

Result and Discussion

Validity of STEM-basesd E-Modules

The results validity of STEM-based E-Modules are presented in the Table 3.

Tabel 3. The results validity of STEM-based E-Modules

The aspects being assessed	Average of three validator
E-moduls structure	3.51
Content validity	3.21
Presentation validity	3.33
Language aspects	3.50
Validity score	73.25
Criteria	Valid
Overall aspects average	3.38
Category	good

Based on the validation results from three validators, it was found that average 73.25% were included as valid criteria. While the average of all aspects, namely e-module systematics, content feasibility, STEM integration, presentation feasibility, and linguistic aspects, was found to be 3.38 which is classified as a good category. This validation test is base on several aspects, including: The structure of the E-Module, consisting of module identity, introduction, objectives, instructions, content, summary, keywords, questions, answers to questions, and references. The suitability of content and STEM integration, covering the completeness of E-Module materials, the accuracy of concepts, content currency, inclusion of STEM components, and the presence of creative thinking indicators. The suitability of presentation, including the quality of E-Module media, engaging information, writing format, and E-Module illustrations. Language-related aspects, including encompassing sentence structures that are easy to understand, conformity with language norms, adherence to standard language guidelines, and communicative language use.

In the terms of the structure E-Modules, an average score of 3.51 was obtained, which categorized as very good. This indicates that the E-Modules complies with the elements required for E-Modules development. In the terms of the reasibility of the content, an average of 3.21 was obtained, which means good. The content of the e-module had contained STEM aspects and can measure creative thinking skills. As for the presentation aspect, an average of 3.33 was obtained which is classified as good. It can be interpreted that ini terms of presentation of material, design, illustrations are interesting. From the linguistic aspect, an average pf 3.51 is obtained which is classified as very good, it is proven that the language used can be easily understood and communicative. In the validation of e-modules, the overall average of 3.38 aspects is obtained, which is classified as a good category. So, can be concluded that this STEM-based e-module is valid and can be tested on students. This e-module was developed by providing illustrations and interesting content with pictures and videos that support learning.

Reliablity of STEM-basesd E-Modules

The results reliability of STEM-based E-Modules are presented in the Table 4.

Tabel 4. The results Reliability of STEM-based E-Modules

ΣX^2	101250	63000	73125	48000	285375
N					
Variant	9195.86	5720.08	6640.49	4357.68	
Σ Variant			4357.68		
Total Variance			952.70		
n Question			4		
r11			0.80		
Category			Tall		

Table 4 shows the test reliability results for E-modules, which 0,8 with category as good. Based on the results of the reliability calculation, it shows that the results if the test reliability analysis (r11) are 0.80 which shows a high reliability category. This states that the items have met the criteria and are reliable so that they can be tested on students the data N-gain score. The pretest and posttest data will be analyzed using the T-test and N-gain test to determine the effectiveness of learning using STEM-basesd E-Modules in enhancing creative thinking skills, are presented in Table 5 and Table 6.

Tabel 5. The results data N-gain Score

Prestest score	Posttest score	N-Gain (%)
25.0	75.0	66.67
25.0	75.0	66.67
25.0	87.0	82.67
44.0	81.0	66.07
37.0	94.0	90.48
31.0	75.0	63.77
25.0	69.0	58.67
25.0	75.0	66.67
25.0	94.0	92.0
25.0	81.0	74.67
25.0	81.0	74.67
	ΣX	72.90

Table 6. Descriptives N-gain

	Class			Statistic	Descriptions Std. Error
Gain percent	Kontrol	Mean		72.99	3.33
		95% Confidence Interval for Mean	Lower Bound	65.56	
			Upper Bound	80.43	

The data from pretest and posttest, which measure students' creative thinking skills, will be further analyzed using the T-test and N-Gain test. Based on table 6, the T-test results show that sig (2-talled) is 0.00 < 0.05, concluded that there was a significant difference between the results before and after the test. This means that the STEM-based e-module has a significant effect on improving creative thinking skills. Shows the average N-win score based on N-win calculation results in reaches 72.90% which is classified as a fairly effective with high category. This shows that learning using STEM-based e-modules is effective enough to train students'creative thinking skills. Supported by (Zan et al., 2023), research, the use of STEM-based e-modules enhances students' creative thinking abilities in mathematics. Research (Nazifah & Asrizal, 2022), the e-modules integrated with STEM approach enhances studentability to think critically and creatively, leading to meaningful learning.

The development of the E-Modulesis based on the integration of STEM aspects, which include Science, Technology, Engineering, and Mathematics with the aim of enhancing creative thinking skills (Kurniati et al., 2021); (Hidayah et al., 2023). The content of this STEM-based E-Module is designed to be engaging and includes a module cover, an introductory section with voice narration, learning instructions, content, summaries, keywords, practice exercises, answer keys, and references. Google Forms-based exercises are embedded within the E-Module. These exercises are designed to measure creative thinking indicators such as fluency, flexibility, originality, and elaboration. Below is a description of the final appearance of the E-Module product. The E-Module can be accessed using the provided link https://bit.ly/e-modul-ekosistem-kelas10.

Figure 1. STEM Based E-Moduls

The STEM-Based E-Modules that have been developed meet the standards of validity both empirically and theoretically (Oktarina et al., 2023). These E-Modules are designed with features that support independent learning in distance education. They include images and videos to aid learners in understanding the material. Additionally, they can promote a sensee of responsibility and discipline when completing exercises via the provided links. Futhermore, the E-Modules include questions that require student to engage in high-order thinking, such as fostering creative thinking (Fitri et al., 2023). Thinking to find solutions of problems. In line with the characteristics of self-instructional E-Modules, learners use them according to the provided instructions and do not depend on others.

E-moduls are a form of innovatioan carried out to support learning activity and can improve student abilities. E-Modules have the advantage of being able to stand alone so they can improve the quality of learning (Marnah et al., 2022). E-module is a mobile-based device

that helps the students studying from their home or wherever and whenever by using their smart phone, tablet or laptop (Kumar Basak et al., 2018). In line with the research (Hunaidah et al., 2022), it is, revealed that digital modulus (E-modules) have been designed to facilitae independent learning for students', aiming to enhance their learning outcomes. According to (Nurhayati et al., 2021), STEM-Based E-modules can cultivate critical thinking patterns and provide competencies that are competitive in the 21st century. The STEM approach refers to the integration of science, technology, engineering principles, and mathematics.

Based on the results of the students' response questionnaire after learning assisted by STEM-based e-modules on ecosystem material. The results of students' responses to e-modules were 100% of students stated that they had never learned using e-modules. While the response of students to using the e-modules, 100% of students stated that they enjoyed learning with e-modules. However, a small number of 18.10% of students are still unable to operate the e-module. The use of e-modules makes students able to understand the material provided by 90.90%. In group activities, 100% of students participated actively and were able to express their opinions after receiving the material contained in the e-module. The response of students after applying it, as much as 72.20% was able to improve the learning outcomes of students after being given practice questions that were able to measure creative thinking skills. The exixtence of STEM-based e-modules is able to become a reference for other sources besides the LKS provided from school. In addition, e-modules can also be accessed without time limit so that students can learn independently.

The response to the STEM- based e-module received a positive response between 72.70% - 100%, so it can be said that learning using e-modules is quite efficient. From these results, the average assessment of the practicality test result was 86.20%, this means that e-module can actually be used for learning. This is support by (Rusmansyah et al., 2023), showed the results of response to an e-module were categorised as very good when viewed from five indicators, namely the readability of the e-module, the practicum presented, aspects of material, learning and motivation.

Conclusion

Based on the results of research and discussion, it can be concluded that STEM-based E-module as a learning media and resource is declared valid based on logical and empirical validity test. Effectiveness of e-module in training students' creative thinking skills is in the effective with high category. The e-module is efficient enough to used in learning for improvement creative thinking skills.

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Author's Contribution
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Conflict of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

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