JPPIPA 9(7) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of E-Module with STEM Nuances to Improve Students' Creative Thinking Skills

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Received: May 3, 2023
Revised: June 22, 2023
Accepted: July 25, 2023
Published: July 31, 2023

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DOI: 10.29303/jppipa.v9i7.4417

Abstract: One of the factors for improving the quality of education in schools is teaching materials. Based on the results of observations at SMAN 1 Sitiung that students have not used e-modules but use electronic teaching materials in the form of pdf files downloaded from the internet and only in the form of writing and a few pictures. Based on the results of the questionnaire, it is known that students have difficulty understanding the concept of the respiratory system material. This causes low student learning outcomes. Based on the results of the creative thinking questionnaire, it was found that students' creative thinking ability is still low with an average score of 33.8, so it is included in the less creative category. So it takes teaching materials that can help in visualizing the subject matter. This type of research is Plomp model development research which consists of three stages, namely the initial investigation stage, the development or prototyping stage, and the assessment stage. The research subjects were class XI students at SMAN 1 Sitiung for the 2022-2023 academic year. Validation results by the validator on nuanced e-modules *Science Technology* Engineering And Mathematics (STEM) shows an average grade 88.05% (very valid). Practical results by Biology teachers showed an average score of 87.5% (very practical) and 88.28% students (very practical). The test data for the effectiveness of creative thinking was obtained from the average essay questions 81.22% (very creative).

Keywords: Creative thinking; E-module; Science Technology Engineering and Mathematics (STEM)

Introduction

Creative thinking is a mental activity to be able to develop or find original, aesthetic, constructive ideas related to conceptual views, and generally places more emphasis on aspects of intuitive and rational thinking. A person's creative thinking can be shown in various ways such as thinking habits, attitudes, traits or personality, skills in solving problems (Nurjan, 2018).

Creative thinking skills are very necessary owned by every student to be able to create and update various innovative new breakthroughs, and be able to solve learning problems as well as in everyday life quickly and precisely. Based on the results of the questionnaire about creative thinking for students, it was found that students' creative thinking ability was still low with an average value of 33.8, so it was included in the less creative category. This is known based on the questions given based on indicators of creative thinking, students are not able to answer the questions correctly.

Creative thinking skills are very much needed in the demands of the 21st century. The ability of 21st century skills is very important for students to solve various problems that arise with logical reasoning and the right solutions. In the 21st century, high-quality human resources are needed who have high-level thinking skills, including critical, creative thinking, and so on (Makhrus et al., 2019).

Creative thinking skills need to be improved in students so that students can answer the problems they face in their own lives (Hagi et al., 2021). The ability to think creatively is also needed in the mathematical process, especially in the process of formulating problems and solving them (Hamidy & Jailani, 2019).

How to Cite:
Wulansari, K., Irdawati, Razak, A., Chatri, M., & Fajrina, S. (2023). Development of E-Module with STEM Nuances to Improve Students' Creative Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5540-5546. https://doi.org/10.29303/jppipa.v9i7.4417

Creative thinking skills are also included in divergent thinking, namely spreading or expanding thinking where a person can bring up many ideas from one initial idea or topic (Noperman, 2022). Not everyone has creative thinking skills that are present from birth, therefore it is necessary to hone and help use the brain in different ways (Abubakar et al., 2021).

One of the factors that can support to improve creative thinking skills is e-module. E-module is a teaching material packaged digitally. E-module can help teachers facilitate students in learning (Asrial et al., 2020). Diantari et al. (2018) states that e-modules are digital learning media that are arranged systematically so that students can learn independently and solve existing problems. It can be concluded that e-modules are digital teaching materials that are systematically arranged and presented in electronic form. E-module can increase students' interest and motivation in learning.

E-module has an important role in the learning process that can assist teachers in explaining subject matter. The advantage of e-module compared to other print media is that it is interactive, e-module can be accessed via mobile phones, laptops or computers. So that the e-module can be used as one of the best alternatives to increase the understanding of students, and can improve the learning outcomes of these students (Pramana et al., 2020).

Based on the results of observations made in July 2022, students have not used e-modules but have used electronic teaching materials in the form of pdf files downloaded from the internet and only in the form of writing and a few pictures. In addition, the teaching materials used by students during the learning process are only in the form of textbooks and learning support books (student worksheets) and are still very limited, causing a lack of learning resources for students and teaching material sources for teachers. Therefore, with such a learning process it results in students only getting material from the teacher (only as recipients of information) which can result in relatively low creative thinking skills.

To overcome these problems, it is necessary to develop an e-module for biology class XI high school with a STEM nuanced approach. STEM is an acronym for Science Technology Engineering Mathematics which means an integrated learning approach that connects real-world applications with classroom learning which covers four disciplines, namely natural sciences (science), technology, engineering results, and mathematics (Gustiani et al., 2017).

The STEM approach has the expected goal of being able to deliver students to fulfill 21st century abilities, namely learning and innovation skills which include critical and creative thinking, being able to solve problems, being creative and innovative, being able to communicate and collaborate, and being skilled at using media, technology, information and communication (ICT) (Winarni et al., 2016).

STEM learning is a collaboration of the four fields of knowledge that are compatible with problems that occur in the real world (Torlakson, 2014). In accordance with previous research conducted by Suryani et al. (2020) said that STEM-based digital modules are able to attract student motivation and improve students' abilities to learn independently.

The application of the STEM approach can be linked to Biology subjects. This is evidenced by the results of research Umbara (2022) regarding the Development of STEM Nuanced E-module to Improve Student Learning Outcomes in Animal Waste Materials for class XI SMA found that there are differences in learning outcomes between the control class and the experimental class, which is based on the results of the pre-test and post-test. The experimental class got an average N-Gain score higher than the control class.

Based on the problems that have been raised, this research is important to do, because students can have e-modules as learning resources and students can also improve creative thinking in accordance with the demands of the 21st century through the use of e-modules. Therefore, research was conducted on the Development of Biology E-modules with the Nuances of Science Technology Engineering and Mathematics (STEM) to Improve Creative Thinking Skills.

Method

This type of research is development research or called Research and Development (R&D). This study aims to determine the validity, practicality, effectiveness of biology e-module based on science technology engineering and mathematics (STEM) to improve students' creative thinking at SMAN 1 Sitiung. This research began in the even semester of January-June at SMAN 1 Sitiung for the 2022/2023 academic year. The research was conducted at the Faculty of Mathematics and Natural Sciences (FMIPA) Padang State University (UNP) and SMAN 1 Sitiung. The subjects of this study were 33 class X students of SMAN 1 Sitiung, three lecturers from the Department of Biology FMIPA UNP and one Biology teacher at SMAN 1 Sitiung. The object of this research is a STEM based biology e-module using the Plomp model (T. Plomp, 2013).

E-Module Validation Instrument by Experts or Experts

The STEM nuanced e-module validation instrument sheet is used to determine the validity of the

STEM nuanced e-module being developed. Questionnaire is a list of questions given to other people who are willing to respond according to user requests. This validity sheet is filled in by expert lecturers or experts.

To determine the level of validity of e-module with STEM nuances, it can be determined using the criteria from Riduwan (2015) as shown in Table 1.

Table 1. E-Module Validity Criteria

Validity Value (%)	Category
0–20	Invalid
21–40	Invalid
41–60	Valid Enough
61–80	Valid
81–100	Very Valid

Practical Instruments

The practicality instrument was carried out using a questionnaire to find out the response of teachers and students regarding the practicality of the product being developed. This practicality sheet is in the form of a questionnaire filled out by teachers and students who have carried out learning using the e-module nuanced STEM.

To determine the practical value of the e-module with STEM nuances, it is determined using modified criteria from Riduwan (2015) which can be seen in Table 2.

Table 2. E-Module Practicality Criteria

Practicality Value (%)	Category
0 – 20	Impractical
21–40	Less Practical
41–60	Pretty Practical
61–80	Practical
81–10	Very Practical

Effectiveness Instrument

This instrument is used to collect effectiveness data, namely affective domain observation sheets (attitudes), psychomotor observation sheets (skills) and test assessment sheets for cognitive domain learning outcomes (knowledge). The competence of students is used to determine the percentage of success of students after participating in learning using STEM nuanced e-modules.

Assessment of creative thinking skills uses a question sheet in the form of five essay questions. This essay question aims to assess the creativity of students in writing answers to the final test after learning activities.

The results of students' answers are calculated based on individual completeness and the class average value obtained from students' creative thinking skills. The criteria for the percentage of assessment of creative thinking skills can be seen in Table 3.

Table 3. Criteria for Assessment of Creative Thinking Skills (Ekawati, 2011)

The Value of Creative Thinking	Criteria
0-20	Not creative
21-40	Less creative
41-60	Pretty creative
61-80	Creative
81-100	Very creative

Result and Discussion

The STEM approach is an approach in education where Science, Technology, Engineering, Mathematics are integrated with the educational process focusing on solving problems in real everyday life as well as in professional life (Davidi et al., 2021). The STEM approach shows students how concepts, principles, techniques, science, technology, engineering and mathematics (STEM) are used in an integrated manner to develop products, processes and systems that benefit human life (Utami et al., 2017). Students are required to actively use technology products in learning with the STEM approach (Kaniawati et al., 2015). STEM learning connects material with life, involves students in practice, guides students in practice, utilizes technology, uses active student learning strategies, communicates actively with students, and gives assignments in groups. The integration of STEM learning with simple technology can help in understanding a material and improve thinking skills (Yusuf et al., 2019).

The purpose of making a learning e-module is so that teachers and students: (a) can clarify and simplify the presentation of messages so that they are not too verbal; (b) to overcome the limitations of time, space, and senses; (c) appropriately and varied to increase motivation and enthusiasm for learning; (d) enable independent learning according to their abilities and interests; (e) can measure and evaluate the learning process and output themselves (Lumbantobing et al., 2019).

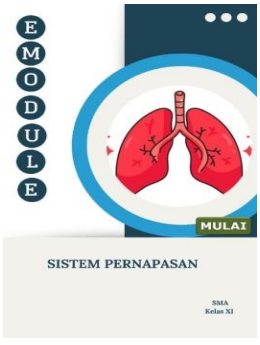

Figure 1. Display of STEM-based e-module

At the development or prototyping stage, the results obtained from the initial investigation stage are used as a guideline for developing STEM-based e-modules on human respiratory system material. Making the e-module is done using the Adobe Flash Professional CS6 program. The appearance of the e-module that has been created can be seen in Figure 1.

Validation

E-Module can be used when it has met the appropriate criteria. The feasibility of Science, Technology, Engineering and Mathematics (STEM)-based E-Modules is measured through the validation results of experts starting from material, media, and evaluation experts. The type of data resulting from expert validation is in the form of quantitative descriptive data, in which the data is in the form of numbers which are analyzed in the form of sentences (Mulyasari et al., 2021).

The formative evaluation used is in the form of an e-module validation sheet nuanced STEM. The quality criterion to be obtained from this stage is the validity of the product that has been made. Experts validate the e-module nuanced STEM namely by three lecturers as validators. Results of e-module validity nuanced STEM can be seen in Table 4.

Table 4. E-Module Validation Results Nuanced STEM

Rated Aspect	Validity Value (%)	Criteria
Construct Aspect	88.33	Very Valid
Content Aspect	88.89	Very Valid
Graphic Aspect	87.5	Very Valid
Language Aspect	87.5	Very Valid
Total	352.22	Very Valid
Average	88.05	

Data Table 4 shows that the requirements to meet e-module validity criteria nuanced STEM has been fulfilled. This can be seen from the overall average value of e-module validity nuanced STEM namely 88.05% with very valid criteria. Therefore, e-module nuanced STEM on the materials of the digestive system and respiratory system that are developed can be used for the next stage.

Another study by Doyan et al. (2023) entitled Improving Critical Thinking Skills Through the Development of STEM-Based Physics Learning Media at Temperature and Heat obtained expert validation results of 0.94 indicating that digital calorimeter media is very valid to use to facilitate increased thinking critical students. The relevance of the two was stated to be very valid by experts, thus indicating that the development of STEM-based E-modules with Human Respiratory System material was worthy of being used as a learning resource.

Practicality

After the improvement process from the expert validation stage and one-to-one evaluation, then the e-module nuanced STEM, then a practicality test is carried out by a small group. At this stage, four students with different learning outcomes (high, medium and low) were evaluated. The practicality test by small group students aims to see the practicality of the e-module nuanced STEM on the digestive and respiratory systems. The results of the small group practice can be seen in Table 5.

Table 5. Small Group Practicality Test Results

Assessment Aspects	Average (%)	Criteria
Ease of use	83.3	Very Practical
Efficiency of learning time	100	Very Practical
Benefit	91.67	Very Practical
Total	275	Very Practical
Average	91.67	

The data in Table 5 shows that the practicality test results in the small group are with an overall average of 91.67% with very practical criteria. This shows that the e-module nuanced STEM developed can already be used and very practical to use during the learning process. So that it can proceed to the assessment phase by conducting large group trials (field tests).

The average results of the practicality of e-modules with STEM nuances by large group students (field tests) can be seen in Table 6.

Table 6. Results of the Large Group Practicality Test (Field Test)

Assessment Aspects	Average (%)	Criteria
Ease of use	88.75	Very Practical
Efficiency of learning time	87.5	Very Practical
Benefit	88.61	Very Practical
Total	264.86	Very Practical
Average	88.28	

The data in Table 6 shows that the results of the STEM nuanced e-module practicality test by students in large groups (field tests) are an overall average of 88.28% with very practical criteria. This shows that the practicality of e-module with STEM nuances by students is very practical to use from the aspect of evaluating ease of use, efficiency of learning time, and benefits in learning activities.

Another study by Tripripa et al. (2020) entitled Development of a Buffer Solution Module Based on the STEM Integrated Approach stated that students' responses to this module were very good with an average score of 4.3. From the results of student responses, it can be interpreted that the E-Module Based on Science, Technology, Engineering and Mathematics

with Human Respiratory System Material has benefits or is practical for students. According to the responses of students, this E-module can be used as a learning resource.

The results of the study Irwandani et al. (2017) state that digital modules are designed to enable students to learn independently to improve learning outcomes. In this designed STEM-based e-Module, features are provided that support student learning activities independently. The developed e-module is more interactive, namely there are picture and video media that function properly, which help students observe objects so as to increase their understanding and creativity. With this e-module, it is expected that students can practice independently, learn to develop logical thinking, creativity and reasoning.

Effectiveness

The value of creative thinking skills is obtained through the implementation of the final test in the form of essay questions/descriptions given to students in the experimental class and control class. Work on the final test questions is carried out at the end of the learning meeting. This assessment is used to see the effectiveness of STEM nuanced e-modules. The results of the average value of creative thinking can be seen in Table 7.

Table 7. Average Results for Creative Thinking Skills

Class	Min Value	Maximum Value	Amount	Average
Experiment	70	95	2599	81.22
Control	70	90	2278	75.17

Based on Table 7, it was found that the average value of the experimental class' creative thinking was higher than the average value of the control class. The experimental class was given treatment using STEM-nuanced e-modules, while the control class did not use STEM nuanced e-modules. The average value of the experimental class is 81.22 in the very creative category, and the average value of the control class is 75.17 in the creative category.

Students can be said to have good creative thinking skills if they fulfill the characteristics of the indicators of creative thinking skills (Ahmad et al., 2022). There are 5 indicators of creative thinking, including (1) Fluency, namely the ability to generate many ideas, ways, suggestions, questions, ideas, or alternative answers smoothly in a certain time quickly and with an emphasis on quality; (2) Flexibility, including the ability to issue varied ideas, answers or questions where the ideas or answers are obtained from different perspectives by changing the way of approach or thinking; (3) Originality, namely the ability to issue expressions, ideas, or ideas to solve problems or make combinations of parts or elements that are unusual, unique, new that no one else has thought of; (4) Elaboration (detail), is the ability to enrich, develop, add, describe, or detail the details of the idea object, main idea or situation so that it is more interesting; (5) Metaphorical thinking, is the ability to use comparisons or analogies to make new connections (Treffinger et al., 2002).

Creative thinking skills should be grown in every education in Indonesia. With good creative thinking skills, it is hoped that it can support students' motivation in learning so that it has a positive impact on learning outcomes (Hamidy & Merliza, 2019), or captures learning because these skills invite students to solve problems from many different points of view. In addition, creative thinking skills can have the opportunity to create student personality development through efforts to increase learning focus, intelligence in learning and self-confidence (Mulyadi et al., 2016). By increasing students' creative thinking skills, it is hoped that human resources in Indonesia, especially the younger generation, can become superior seeds to make Indonesia even more advanced both in the economic and other fields (Kharisma, 2021).

Conclusion

Based on the research results, the following conclusions are obtained. E-module nuanced Science Technology Engineering and Mathematics (STEM) has a validity value of 88.05% with very valid criteria in terms of the construct aspect, the content aspect, the graphic aspect, and the language aspect. E-module nuanced Science Technology Engineering and Mathematics (STEM) has a practical value by teachers of 87.5% and students of 88.28% with very practical criteria in terms of ease of use, efficiency of learning time, and benefits. E-module nuanced Science Technology Engineering and Mathematics (STEM) has effectiveness with very effective criteria in terms of the assessment of creative thinking skills of students.

Author Contributions

Kurnia Wulansari conceptualized research ideas, designed methodology, conducted research, analyzed data, management and coordination of responsibility. Irdawati conducts literature reviews and provides suggestions in compiling articles. Abdul Razak, Moraita Chatri and Suci Fajrina provided suggestions in compiling articles.

Funding

This research received no external funding.

Conflicts of Interests

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyzes, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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