

## Integrating STEAM in Teaching Integrals: An Interactive Media Needs Analysis to Enhance Creative Thinking

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### ABSTRACT

This study aims to identify the current conditions of mathematics learning, the obstacles faced by teachers and students, and students' perceptions regarding the need for innovative and interactive learning materials. The focus of this research is the development of an Integral e-module based on the STEAM approach as an effort to stimulate students' creative thinking skills. The research employed a qualitative descriptive method, with data collected through interviews with mathematics teachers and questionnaires distributed to 30 students of class XI MIPA 2 at SMA Muhammadiyah Pakem. The findings reveal that most students experience difficulties in understanding Integral material due to the predominance of lecture-based instruction, unengaging teaching materials, and the limited use of interactive media. A total of 61% of students expressed a preference for e-modules as more favorable learning resources, while teachers acknowledged the importance of developing contextual and activity-based e-modules. The STEAM approach is considered relevant as it connects mathematical concepts with real-life contexts and fosters students' creativity. Therefore, the development of an interactive STEAM-based e-module is regarded as a pedagogical solution to create mathematics learning that is more engaging, effective, and responsive to the challenges of the 21st century.

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### ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi kondisi terkini pembelajaran matematika, hambatan yang dihadapi guru dan siswa, serta persepsi siswa mengenai kebutuhan akan bahan ajar yang inovatif dan interaktif. Fokus penelitian ini adalah pengembangan e-modul Integral berbasis pendekatan STEAM sebagai upaya menstimulasi keterampilan berpikir kreatif siswa. Penelitian menggunakan metode deskriptif kualitatif, dengan data diperoleh melalui wawancara dengan guru matematika dan kuesioner yang dibagikan kepada 30 siswa kelas XI MIPA 2 di SMA Muhammadiyah Pakem. Hasil penelitian menunjukkan bahwa sebagian besar siswa mengalami kesulitan dalam memahami materi Integral karena dominasi metode ceramah, bahan ajar yang kurang menarik, serta terbatasnya penggunaan media interaktif. Sebanyak 61% siswa menyatakan lebih menyukai e-modul sebagai sumber belajar yang lebih baik, sementara guru mengakui pentingnya pengembangan e-modul yang kontekstual dan berbasis aktivitas. Pendekatan STEAM dianggap relevan karena menghubungkan konsep matematika dengan konteks kehidupan nyata serta mendorong kreativitas siswa. Oleh karena itu, pengembangan e-modul interaktif berbasis STEAM dipandang sebagai solusi

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pedagogis untuk menciptakan pembelajaran matematika yang lebih menarik, efektif, dan responsif terhadap tantangan abad ke-21.

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## Introduction

In the era of the Fourth Industrial Revolution, the rapid advancement of technology has significantly impacted various sectors of human life, including the field of education (Isnaini, 2020). This phenomenon necessitates the implementation of an educational model that prioritizes the mastery of 21st-century skills, enabling students to adapt to dynamic societal and technological changes. According to Kasanah et al. (2025) and Syah et al. (2025), these 21st-century competencies encompass critical thinking, effective communication, collaboration, and creativity. In this context, creativity or the ability to think creatively emerges as a key competence required for students to confront increasingly complex and globalized challenges.

Creative thinking can be defined as the capacity to generate original ideas in problem-solving processes and to create innovative solutions that differ from existing approaches (Pimdee et al., 2024). Torrance (1974) identified four essential characteristics of creative thinking: fluency, flexibility, originality, and elaboration. Within the learning process, these attributes empower students to examine problems from diverse perspectives and generate multiple possible solutions. Unfortunately, such skills are still underdeveloped in many classroom environments, often leading to students struggling when faced with complex problem-solving tasks.

In Indonesia, the cultivation of creative thinking skills among students remains limited within the teaching and learning process. Heryuriani et al. (2025) and Weng et al. (2022) emphasize that a lack of stimulation and encouragement from teachers is a major obstacle to the development of student creativity. When teachers primarily focus on one-way delivery of content and rarely promote the exploration of ideas, students become passive learners and are less inclined to develop innovative thinking. This underscores the urgent need for teaching approaches that activate student engagement and foster autonomous and creative thought throughout the learning experience.

The lack of creative thinking ability among students is a pressing concern, especially given that such skills are increasingly essential in navigating modern life and future careers (Wulandari et al., 2024). Without the development of these abilities, students may find it difficult to adapt to fast-paced changes and overcome complex global challenges. Susetyarini et al. (2022) and Rochmat et al. (2025) stress that the Indonesian education system must place

greater emphasis on enhancing students' creative thinking capabilities, particularly through innovative, engaging, and future-oriented teaching methods.

In mathematics education, creative thinking plays a critical role due to the inherently abstract and challenging nature of mathematical concepts (Toheri et al., 2020). Tanudjaya & Doorman (2020) argue that today's educational landscape must equip students with the 4Cs critical thinking, creativity, collaboration, and communication which are indispensable in the Fourth Industrial Revolution. Among these, creativity becomes especially crucial when students tackle complex topics such as integral calculus. Kintoko et al. (2025) and Astiwi et al. (2024) further assert that students' ability to think creatively greatly influences their capacity to understand and apply mathematical concepts in real-life contexts.

To address these needs, the integration of the STEAM (Science, Technology, Engineering, Art, and Mathematics) approach is considered effective for fostering students' 21st-century skills. Alam et al. (2025) state that the STEAM approach encourages critical and creative thinking by combining multiple disciplines within authentic, real-world contexts. Specifically in mathematics instruction, particularly on abstract topics such as integrals, STEAM can aid students in conceptualizing mathematical ideas more concretely. Jayanti et al. (2022) and Sari & Sutihat (2022) highlight that the use of STEAM-based e-modules not only increases student interest and engagement but also facilitates interdisciplinary connections and promotes active participation in solving contextual and creative problems. However, to date, research debate continues regarding the application of the STEAM approach in mathematics learning, particularly on integral topics, to foster students' creative thinking skills. Most previous research has focused solely on cognitive aspects and learning outcomes, while in-depth exploration of how STEAM can develop students' creativity remains limited.

## Method

This study employed a qualitative descriptive approach with the objective of analyzing the percentage of needs for interactive e-modules in mathematics learning. Data were collected through interviews with mathematics teachers at SMA Muhammadiyah Pakem and questionnaires distributed to 30 students of grade XI MIPA 2. The research was conducted in May 2025, with the sample selected using a purposive sampling technique based on the criterion of students who had previously studied Integral material. The research instruments consisted of an interview sheet for teachers and a questionnaire for students to identify learning needs. The teacher interview sheet comprised 20 questions covering aspects such as students' learning conditions, teaching methods, instructional materials and media used, students' level of creative thinking, and teachers' perspectives on the importance of developing interactive e-modules in mathematics learning.

The collected data were analyzed using a qualitative descriptive analysis by combining thematic analysis and descriptive statistics. The interview data from teachers were analyzed through several stages: transcription, in-depth reading, identification of patterns or categories, and formulation of key themes reflecting the learning conditions and the need for interactive e-module development. Meanwhile, the questionnaire data from students were analyzed using descriptive statistics by calculating the percentages and mean scores of each indicator to describe the level of students' needs for interactive e-modules and their perceptions of

mathematics learning on integral topics. The results of both analyses were then interpreted integratively to provide a comprehensive understanding of the need for developing STEAM-based interactive e-modules as an effort to enhance students' creative thinking skills in mathematics learning.

## Results and Discussion

Various aspects of human life have undergone significant changes due to the increasingly rapid development of technology, especially in the field of education. Students' creative thinking skills must be maximized when we recognize the challenges of the 21st century. Therefore, appropriate open-ended materials are needed to encourage student creativity in mathematics learning. A STEAM-based e-module focusing on Integral material, which is expected to support mathematics learning, is based on findings from questionnaires and interviews conducted with teachers in grade 11 of SMA Muhammadiyah Pakem. The following table shows the results of interviews with teachers.

Table 1. Results of Interviews with Teachers

No	Question	Response
1	How many 11th grade students are there in Mathematics and Natural Sciences at SMA Muhammadiyah 1 Sleman?	There are only two classes: XI MIPA 1 and XI MIPA 2.
2	How many students are in each class?	Each has 30 students.
3	Which of these classes are less active in learning?	The most active class is in XI MIPA 2, while in XI MIPA 1, the students are evenly distributed.
4	What causes these students to be less active?	This is due to several factors, including friends and even homeschooling brought to school.
5	What do you do to make the class more active and conducive?	Icebreakers are held before the lesson, and the teacher then appoints students to answer spontaneous questions related to the previous lesson.
6	What kind of teaching materials do you use during your lessons?	Sometimes I use printed books and sometimes I use worksheets purchased from the publisher.
7	What learning resources do you frequently use in your lessons?	Printed books.
8	How often do you use the internet?	I rarely use the internet.
9	What learning media do you frequently use in your lessons?	I rarely use learning media due to limited school facilities. Occasionally, I use my cell phone and LCD.
10	Which of these media do you use most often?	LCD
11	What are your opinions regarding students' creative thinking skills?	Very important because in this era, many problems can be solved through students' creative thinking.
12	Based on the teaching materials, learning resources, and learning media you have used, how has the	Still low, as seen from test results, which contain several indicators of creative thinking.

development of high school students' creative thinking skills progressed?

<p><b>13</b> Do you often train your students' creative thinking skills during lessons?</p> <p><b>14</b> Have you ever used interactive e-modules?</p> <p><b>15</b> In your opinion, what kind of interactive e-modules are best for use in learning?</p> <p><b>16</b> What learning approaches do you use in your lessons?</p> <p><b>17</b> Have you ever used the STEAM approach?</p> <p><b>18</b> What math materials do you think are suitable for the STEAM approach?</p> <p><b>19</b> Are there any challenges with integrals?</p> <p><b>20</b> How do you convey integrals to your students?</p>	<p>Not yet, because during my teaching I only refer to student worksheets.</p> <p>Not yet.</p> <p>E-modules containing several meaningful activities for students according to the learning approach.</p> <p>Scientific approach.</p> <p>Not yet.</p> <p>Integral is one suitable approach.</p> <p>Yes, there are many obstacles, such as students having difficulty memorizing formulas.</p> <p>Implemented through lectures, several assignments, and presentations.</p>
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Based on interviews conducted with the mathematics teacher at SMA Muhammadiyah Pakem, there are two science classes for Grade XI students at the school, namely XI MIPA 1 and XI MIPA 2, each consisting of 30 students. Among these two classes, XI MIPA 2 stands out as the class with the highest level of student engagement compared to the others. The students in this class actively engage in argumentation, participate in discussions, and demonstrate strong creative thinking abilities. However, several factors contribute to the lower level of student participation in other classes, such as variations in classroom conditions. Some classes consist of students who are more responsive to the learning materials and display higher levels of interest, whereas others tend to be noisier, which results in a less conducive learning environment. According to Hanama et al. (2024) and Siswanto & Firmansyah (2024) a lecture-dominated teaching method can also be a contributing factor to the low levels of students' creative and critical thinking skills.

In addition to classroom conditions, the use of teaching materials also plays a significant role in supporting the learning process. The teaching materials currently used include handouts, government-issued printed textbooks (BSE), and student worksheets (LKS). However, interactive e-modules have not yet been implemented in the learning process due to limited access to supporting facilities. Dependence on materials provided by the government or fellow teachers has led to minimal innovation in instructional practices. Therefore, it is crucial for teachers to recognize the importance of developing appropriate teaching materials and to understand their benefits in the preparation of lesson plans (Tarlo et al., 2025). According to the mathematics teacher, interactive e-modules are seen as a potential solution to this problem.

Caesaria et al. (2024) and Mala et al. (2025) emphasize that an effective e-module should have an attractive design, comprehensive content, clearly defined learning objectives and indicators, and utilize a learning approach that enhances the students' learning experience. At SMA Muhammadiyah Pakem, the learning resources for mathematics are limited to printed

textbooks and materials sourced from the surrounding environment. The school's limited facilities, including a policy that prohibits students from bringing mobile phones, hinder the use of the internet in classroom activities. The instructional media employed are also limited, with teachers primarily using visual aids such as images and models (torso) to support classroom learning.

The instructional approach implemented is the scientific approach, which emphasizes learning through observing, questioning, gathering information, and communicating (Naufal et al., 2025; Saleh et al., 2025). Although the STEAM-based approach has not yet been applied, the mathematics teacher acknowledged that this approach would be highly beneficial in supporting mathematics learning, particularly in solving real-world problems. One of the mathematics topics deemed suitable for integration with the STEAM approach is the concept of energy, which includes the topic of integrals (Trisnowali & Arifin, 2023). However, challenges remain in teaching this topic, such as the large number of formulas students are required to understand and the predominance of lecture-based instruction, which often results in passive student participation.

According to the interview with the mathematics teacher at SMA Muhammadiyah Pakem, the development of interactive e-modules is considered essential for supporting student learning both at school and at home. The teacher stated that interactive e-modules would provide students with flexible access to learning materials and practice exercises. A well-designed e-module for mathematics learning should be attractive, interactive, and capable of fostering students' 4C skills, including creative thinking (Fitriana et al., 2025). Moreover, e-modules should include student activities that are relevant to real-life phenomena. Subsequently, several statements were prepared for students to assess the need for developing a STEAM-based e-module on the topic of integrals. These statements are presented in the following table.

Table 2. Statement Codes in the Needs Analysis Questionnaire

<b>Code</b>	<b>Statement</b>
<b>A</b>	Mathematics is difficult to understand
<b>B</b>	Integrals are difficult
<b>C</b>	I have difficulty with integrals using the media provided by the teacher
<b>D</b>	I need interactive learning media
<b>E</b>	I enjoy using e-modules as learning media
<b>F</b>	I enjoy learning integrals using e-modules
<b>G</b>	I understand them better when I relate integrals to everyday life
<b>H</b>	The media used by the teacher trains my creative thinking skills

After students were given a questionnaire related to needs analysis, the results were obtained, as in the following figure.

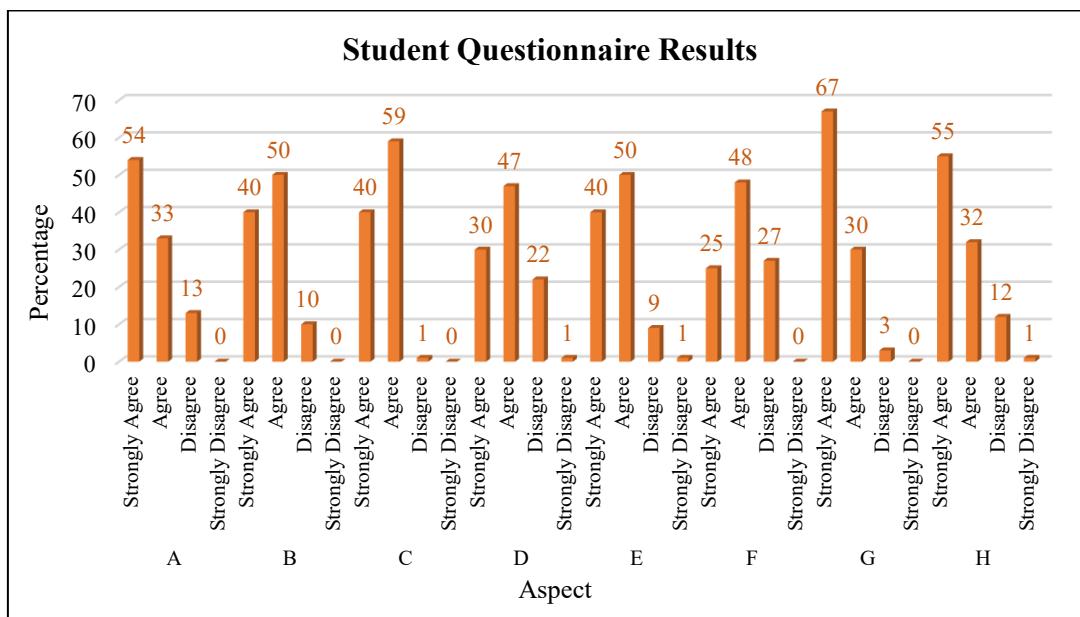


Figure 1. Results of the Student Needs Analysis Questionnaire

The survey results indicate that most students still perceive mathematics as a difficult subject, with 54% strongly agreeing and 33% agreeing that mathematics is hard to understand. This difficulty becomes more prominent in the topic of integrals, where 40% of students strongly agreed and 50% agreed that integrals are challenging material. These findings are consistent with Ijijati & Elfita (2024) and Mensah et al. (2023), who noted that integrals are often among the most difficult topics in the senior high school mathematics curriculum due to their abstract nature and the need for a strong understanding of derivative concepts as well as algebraic applications.

Students' difficulties in understanding integrals are further reinforced by the fact that 99% of them (40% strongly agree, 59% agree) experienced obstacles when using the instructional media provided by their teachers. This indicates that conventional media have not fully supported students' needs. This result aligns with Kintoko & Siswanto (2024) and Tarso et al. (2025), who found that monotonous teaching media reduced students' motivation to learn mathematics. Therefore, there is a need for more engaging, interactive learning media that match the characteristics of the learners.

Furthermore, the majority of students (77%) expressed the need for interactive learning media, with 30% strongly agreeing and 47% agreeing. This reflects a gap between the teaching methods applied by teachers and the expectations of students. Previous research by Daryanes et al. (2023) and Roswahyuliani & Ruchiyat (2024) also emphasized the importance of technology-based interactive media in enhancing students' motivation to learn mathematics. Accordingly, the results of this study affirm that the development of STEAM-based or activity-based e-modules is a relevant solution to address students' needs.

In addition, students showed positive responses to the use of e-modules. A total of 90% of students (40% strongly agree, 50% agree) enjoyed using e-modules as learning media, although 27% still reported difficulties in learning integrals through e-modules. This finding is in line with Alya & Purwaningsih (2025) and Mitra et al. (2024), who argued that e-modules can foster students' independent learning, although their effectiveness largely depends on the

design and interactivity of the modules. Thus, contextually designed and interactive e-modules have the potential to improve learning outcomes in integral topics.

The most notable finding is that 97% of students reported better understanding integrals when they are related to everyday life (67% strongly agree, 30% agree). Moreover, 87% acknowledged that the media used by their teachers enhanced their creative thinking skills. This result is consistent with Fitriana et al. (2025) and Saputra et al. (2025), who highlighted the importance of contextual learning in developing 21st-century skills, including critical and creative thinking. Therefore, the development of STEAM-based interactive e-modules that integrate mathematical concepts with real-life contexts is considered a pedagogical solution to enhance students' understanding and foster their creative thinking skills.

Table 3. Needs Analysis for STEAM-Based Integral E-Module Development

No	Question	Alternative Answers	Percentage
1	How does the teacher deliver learning?	Lecture	68%
		Writing in front	13%
		Dictation	10%
		Using learning media	5%
		Opening textbook	4%
2	What difficulties do you often experience in understanding mathematics material?	Giving explanations	2%
		Learning media is less interesting	20%
		Learning is boring	12%
		Learning resources are lacking	10%
		Learning materials are less interesting	56%
3	What learning activities do you like?	Assignments	16%
		Discussions	39%
		Inquiry	22%
		Problem-solving	23%
		Practice	0%
4	What teaching materials do teachers use?	Textbook	0%
		Module	58%
		E-Module	16%
		Handout	6%
		Worksheet	20%
5	What teaching materials do you like?	Textbook	0%
		Module	33%
		E-Module	61%
		Handout	0%
		Worksheet	6%
6	What kind of learning media can increase your learning motivation?	LCD	14%
		Video	12%
		Image	0%
		Mobile Phone	68%
		PowerPoint Text	6%

Based on the data presented in the table, it is evident that the majority of teachers still employ conventional teaching methods, with 68% relying primarily on lecture-based instruction. Although this method is commonly used, its effectiveness in fostering student

interest particularly in abstract subjects such as Mathematics remains questionable. According to Nugroho et al. (2025), Siswanto (2025) and Wantoro et al. (2025), engaging Mathematics instruction should not rely solely on lectures but should also incorporate various laboratory activities such as experiments, practical work, demonstrations, the use of teaching aids and slide projectors, discussions, and active exploration of concepts through available media. Predominant use of the lecture method often results in a monotonous classroom atmosphere, reduced student focus, and difficulties in understanding the material. The questionnaire results further reveal that this condition is exacerbated by learning materials and media perceived as dull and unengaging by students.

Another factor reinforcing these findings comes from data on Grade XI MIPA 2 students, where 56% reported that the learning materials used in Mathematics classes were uninteresting. This high percentage indicates that a substantial number of students are disengaged from the presented content, negatively impacting their motivation and involvement in learning. These conditions align with the findings of Efendi et al. (2025) and Syah et al. (2025), who state that the poor quality and lack of appeal in instructional materials significantly affect students' interest in learning Mathematics. When learning resources fail to bridge the gap between abstract concepts and real-life applications, the learning process becomes less relevant and harder for students to internalize. Therefore, the need for engaging and contextualized learning materials is urgent in 21st-century Mathematics education.

Meanwhile, questionnaire data also show that 39% of Grade XI MIPA 2 students favor discussion-based methods, as they allow for deeper thinking and consideration of others' perspectives during interaction. This preference reflects students' awareness of the importance of creative and collaborative thinking skills in addressing global challenges. According to Alam et al. (2023), Ananda (2019) dan Arisandy et al. (2021), problem-based learning (PBL) has proven effective in enhancing students' creative thinking abilities. Such skills enable students to systematically analyze problems, generate innovative ideas, and formulate creative solutions to the issues they encounter. Therefore, there is a need for instructional models that actively promote idea exploration and problem-solving, such as interdisciplinary and project-based approaches.

One relevant approach to address these challenges is the STEAM-based learning model (Science, Technology, Engineering, Art, and Mathematics). This approach provides students with the opportunity to explore concepts holistically and integratively, incorporating art as a medium to foster creativity and imagination. STEAM does not merely expand students' conceptual knowledge but also develops critical, collaborative, and communicative thinking skills essential for the 21st century. Furthermore, STEAM-based learning encourages students to connect mathematical concepts to real-world contexts and to solve everyday problems creatively and practically. As such, the implementation of STEAM in Mathematics instruction holds strong potential to enhance both student motivation and deep conceptual understanding.

According to the results of the questionnaire, 61% of Grade XI MIPA 2 students selected e-modules as the preferred instructional materials for Mathematics learning. Students expressed high interest in interactive e-modules containing videos, images, animations, and other visual elements that support enjoyable concept comprehension. This confirms that the demand for engaging instructional materials aligned with the characteristics of the digital generation is a

priority in the learning process. As stated by Maarang et al. (2023), Nur & Nugraha (2023) dan Ramadhan (2023), the application of the STEAM approach in Mathematics education has been shown to significantly enhance student creativity. By utilizing STEAM-based e-modules, students are not only supported in visually and contextually understanding integral concepts but are also stimulated to develop creative thinking skills. Therefore, the needs analysis through questionnaires and teacher interviews highlights the importance of innovation in developing a STEAM-based e-module on Integral topics as an adaptive and relevant pedagogical solution.

Based on teacher interview data, most educators acknowledged that the persistence of lecture-based instruction stems from several contextual constraints, such as limited instructional time, a dense curriculum, and insufficient technological proficiency. Teachers expressed concern that despite understanding the need for interactive learning, they often revert to traditional approaches due to the pressure of completing the syllabus and assessing students' academic achievement within tight schedules. This teacher perspective aligns with the student questionnaire findings, where a significant majority (68%) reported that their mathematics classes primarily involve one-way explanations with minimal interactive engagement. Consequently, students' passive learning experiences are not merely the result of teacher preference but rather reflect broader structural and pedagogical challenges within the school environment.

Furthermore, both teachers and students identified the quality and attractiveness of learning materials as a key determinant of engagement. Teachers noted during interviews that the available materials mostly static textbooks and worksheets do not adequately contextualize mathematical concepts, particularly abstract ones such as integrals. They admitted difficulty in designing media that could bridge theory with application due to limited digital resources and training. This viewpoint is strongly supported by the questionnaire data, in which 56% of students stated that mathematics materials were uninteresting and lacked real-life relevance, and 20% reported that learning media failed to stimulate curiosity. The convergence of these findings underscores the urgent need for instructional materials that are both contextually meaningful and technologically enriched. Integrating teachers' awareness of this limitation with students' clear demand for engaging, visually supported learning resources establishes a compelling argument for the development of STEAM-based interactive e-modules. Such innovation would not only respond to students' cognitive and motivational needs but also empower teachers to implement creative and student-centered pedagogies within existing curricular constraints.

## Conclusion

The results of the study indicate that students at Muhammadiyah Pakem Senior High School have low creative thinking skills, which is caused by learning activities that tend to be boring and the use of less interesting teaching materials. This is evident from the results of the questionnaire which showed that some students experienced difficulties in understanding Integral material, because the learning process is still centered on the teacher with lecture methods and explanations via the blackboard, thus making students passive. To overcome this problem, interactive and innovative teaching materials are needed to support a more active and meaningful learning process. Therefore, the development of STEAM-based e-modules is a

relevant solution to improve students' creative thinking skills through contextual and challenging activities. Although this study only focused on Integral material, it is recommended that future e-module developments include other materials and use a more innovative approach that is in line with technological developments and the demands of the times.

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