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Facilitating Mathematical Creative Thinking Ability: Analysis of Validation, Practicality, and Effectiveness of Learning Modules

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Abstract: Facilitating Mathematical Creative Thinking Ability: Analysis of Validation and Student Response to Learning Modules. Objective: This study aims to determine the validity and practicality of the developed module of integration technique in integral calculus learning; and to find out whether the module of integration technique in integral calculus learning developed is effective in improving students' mathematical creative thinking ability. **Methods:** The module was developed using the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. Two experts conducted the validation, resulting in an average validity score of 3.67, categorized as very valid. The practicality of the module was assessed through a student response questionnaire, which resulted in an average practicality percentage of 81%, classified as very practical. The effectiveness of the module was evaluated by comparing students' pretest and posttest scores on mathematical creative thinking skills. **Findings:** The analysis showed a significant improvement in students' scores, with the average score increasing from 1.13 in the pretest to 5.06 in the posttest. The average n-gain was calculated at 0.59, which falls into the moderate category. These results indicate that the module is effective in enhancing students' mathematical creative thinking skills. **Conclusion:** The study concludes that the developed learning module effectively improves students' mathematical creative thinking skills and can be utilized as a teaching material in integral calculus courses. The development of this module has significant implications for enhancing the quality of mathematics education in the digital era.

Keywords: mathematical creative thinking, integral calculus, ADDIE model, integration technique.

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INTRODUCTION

Industrial Revolution 4.0 has brought fundamental changes to the structure of work, education, and social interaction through the extensive integration of digital technology into everyday life. This transformation demands adaptation in various disciplines and affects how individuals think and interact with the world (Hamdan, 2018). In education, in particular, this revolution affects teaching methodologies, learning approaches, and the types of capabilities that students must develop to succeed in a digitalized and fast-paced future.

Changes in education are not only limited to adopting new technologies but also include expectations for higher competencies in critical and creative thinking and digital and numerical literacy. Maths, as the foundation of many disciplines in education and its practical application in life, plays an important role in developing these skills. Mathematics is not only a tool for counting or measuring; it also supports

the development of analytical and creative skills that enable students to generate innovative solutions to complex problems (Handoko, 2017).

Given this important role, effective mathematics learning should be implemented consistently at every level of education, from primary school to university. A strong foundation in basic mathematical concepts should be laid at the primary level with engaging and interactive methods to build curiosity and love for mathematics from an early age. As the level of education increases, the complexity of mathematical material also increases, and teaching methods should be adapted to encourage deeper understanding and application of knowledge in more complex scenarios. In higher education, where mathematics is often highly specialized and integrated with other disciplines, it is important to incorporate mathematics learning with practical applications and research, ensuring that students not only master the theory but can also apply it creatively in real problem-solving. Thus, quality mathematics education at every level meets expectations of higher mathematical ability and equips students with the skills necessary to succeed in a world increasingly dependent on technology and innovation.

In reality, mathematics learning at the tertiary level often still focuses on conventional cognitive aspects and provides less space for creative exploration needed in dealing with real-world problems (Arhasy & Mulyani, 2017). Effective learning in the current era should include activities that facilitate deep understanding and application of concepts in various situations, not just mastery of theory. Learning should challenge students to think outside existing frameworks, create new ideas, and apply mathematical knowledge in a broader and more creative context.

Amidi (2018) found that commonly used teaching methods, which focus on understanding and reproducing knowledge through presentations and closed problem-based practical exercises, are often insufficient to stimulate or develop creative thinking. This research suggests that a more open-ended approach, which challenges students to confront non-routine problems and develop original solutions, is needed to enhance creativity and flexibility in thinking. Traditional learning often involves students in a sequential process of remembering, understanding, using, analysing, synthesising and evaluating information, but makes little room for independent work, faces time constraints for analysis, synthesis and evaluation, and tends to teach new topics in an algorithmic way before providing exercises to reinforce them, which results in students' dependence on teachers and reduces their independence in dealing with the complexities of adult life.

Previous studies have shown that innovative learning can stimulate students' mathematical creative thinking skills. Research conducted by previous researchers found that problem-based learning, either given alone or combined with simulation, improves mathematical thinking skills, one of which is mathematical creative thinking ability (Simanjuntak, Hutahaean, Marpaung, & Ramadhani, 2021); (Juandi & Tamur, 2021). More research with different learning strategies also obtained similar results. For example, research found that Creative Problem Solving (CPS) was more effective in improving problem-solving skills and creativity compared to conventional methods (Khalid et al., 2020); (Septian, Budiman, Suwarman, & Yuningsih, 2020). Open-ended and creative problem solving learning models have been proven effective in training students' creative thinking skills in mathematics learning, whether used alone or in combination with other models, with the open-ended model being more effective than creative problem solving and direct instruction in elementary schools (Ali, Amir MZ, Kusnadi, & Vebrianto, 2021; Kartikasari, Usodo, & Riyadi, 2022; Mutiarawati, Dwijanto, & Dewi, 2022; Munahefi, Mulyono, Kartono, & Waluya, 2023). Selective Problem Solving Model (SPS) is

effective in improving students' creativity skills in mathematics (Kirisci, Sak, & Karabacak, 2020). Teaching with a STEM approach creates an atmosphere of enthusiasm that attracts students' interest in mathematics, increasing their learning motivation, creativity and innovation (Jawad, Majeed, & Alrikabi, 2021). The Posing-Exploring-Doing-Evaluating (PEDE) Productive Failure Model significantly improves students' creative thinking ability in mathematics compared to conventional methods, so it is recommended to be used by mathematics teachers in new normal era learning (Casing & Roble, 2021).

In reality, mathematics learning at the tertiary level often still focuses on conventional cognitive aspects and provides less space for creative exploration needed in dealing with real-world problems (Arhasy & Mulyani, 2017). Whereas mathematics learning needs to support the development of intelligence, where intelligence is defined as the general mental ability to learn and apply knowledge in manipulating the environment and the ability to think abstractly (Putri, Hasratuddin, & Syahputra, 2019). Effective learning in the current era should include activities that facilitate deep understanding and application of concepts in various situations, not just mastery of theory. Learning should challenge students to think beyond existing frameworks, create new ideas, and apply mathematical knowledge in a broader and creative context. In line with this Amidi (2018) found that commonly used teaching methods, which focus on understanding and reproducing knowledge through presentations and closed problem-based practical exercises, are often insufficient to stimulate or develop creative thinking. This research suggests that a more open-ended approach, which challenges students to confront non-routine problems and develop original solutions, is needed to enhance creativity and flexibility in thinking.

Learning activities that do not take place optimally, as seen in traditional approaches that do not encourage creativity, will significantly impact student achievement, especially in mathematical creative thinking. Failure to implement innovative and interactive learning methods can hinder the development of critical and creative thinking, essential skills in the modern era. Students may become accustomed to standardized problem-solving routines and lack the training to explore solutions beyond predetermined methods. The impact of this ineffective approach includes difficulties in adjusting to unexpected situations and a lack of ability to apply mathematical knowledge in new contexts or in solvi complex real-world problems.

A study by Faelasofi (2017) showed that university students often achieve low scores in tasks that measure mathematical creative ability, indicating deficiencies in existing mathematics education supporting creative thinking development. This is confirmed by Suripah & Sthephani (2017) research, which found that unequal mastery of mathematical concepts among high, medium, and low ability students can impact their ability to develop creative thinking.

There is still a gap in practical implementation of these methods in higher education in Indonesia, where traditional teaching methods dominate. Additionally, there are other significant gaps that need to be addressed. One major gap is the lack of integration of digital technologies in mathematics education. Despite the potential of digital tools to enhance learning experiences, their adoption remains limited in many institutions. Furthermore, there is a lack of sufficient training for educators in innovative teaching methods and technology use, which hinders the effective implementation of modern pedagogical approaches. Resource limitations also pose a challenge, as some institutions struggle to provide the necessary materials and infrastructure for interactive and engaging learning. Finally, the quality of education varies significantly between urban and rural areas, leading to unequal access to high-quality mathematics education.

To create active and creative teaching and learning strategies, both lecturers and students need to develop their own approaches, by understanding the essence, purpose, motivation, and methods of teaching and learning (Hang & Van, 2020). In line with this statement, lecturers need to design media, strategies, or learning models that are more effective and relevant to the material and context faced by students (Laurens, Batlolona, Batlolona, & Leasa, 2018). Mathematics teachers can also facilitate mathematics learning by using quality teaching materials, especially those based on the Realistic Mathematics Education approach (Hasibuan, Saragih, & Amry, 2018). Therefore, to respond to this need, teaching materials are one of the things that need to be designed to educate about mathematics concepts and facilitate the development of creative thinking skills. Teaching materials are a collection of subject matter designed to fulfil competency standards and basic competencies in accordance with the applicable curriculum (Lestari, 2013).

Research conducted by Novalia & Noer (2019) showed that the use of mathematics learning modules with the PQ4R strategy successfully improved students' mathematical creative thinking skills. Similar findings were also obtained by Citroresmi and her colleagues in 2016, who found that problem-solving oriented mathematics teaching materials were effective for improving students' mathematical creative thinking skills (Citroresmi, Sugiatno, & Suratman, 2016). The next study found that the integration of e-learning into the Resource-Based Learning method improved students' mathematical creative thinking ability and self-confidence better than without e-learning, with the scientific approach contributing positively to learning achievement, and showed an increase in mathematical creative thinking ability in the aspects of fluency, flexibility, originality, and elaboration (Yaniawati, Kariadinata, Sari, Pramiarsih, & Mariani, 2020). The design of number pattern e-modules based on mathematical creative thinking skills using the Kvisoft Flipbook application proved to be valid, practical, and received positive responses from students, making it suitable for use in learning grade VIII mathematics (Setiyani, Waluya, Sukestiyarno, & Cahyono, 2022). The Kudus local wisdom-oriented module effectively improves the mathematical creative thinking ability of students with dyscalculia and receives positive responses from students and teachers (Purwaningrum, Muzid, Siswono, & Masriyah, 2021). The development of an enrichment-based portfolio learning module effectively improves students' creative thinking skills in learning mathematics at SMP Negeri Surakarta (Asri, Joebagio, & Djono, 2019). Based on previous research, researchers are interested in developing teaching materials to facilitate mathematical creative thinking skills.

The teaching materials developed are modules that can be accessed by students online. This is supported by the statement (Adel & Dayan, 2021) that the integration of traditional teaching methods with digital technology can improve students' creative thinking. This means that lectures using modules that can be accessed online can develop students' creative thinking. Through this integration, students not only gain a deep understanding of the subject matter, but also hone their creative and technical skills. This is important to prepare students for future challenges, especially in terms of creativity and leadership.

The novelty of this research lies in developing and implementing an integration technique module in integral calculus learning specifically designed to enhance creative thinking abilities. Unlike previous studies, this research focuses on higher education in Indonesia, addressing the gap between existing theoretical knowledge and practical application in fostering creative thinking skills.

The modules support divergent thinking and student-centered learning techniques, where

lecturers act as facilitators rather than primary teachers. The module aims to allow students to be actively involved in the learning process, find their solutions, and develop unique and personal approaches to mathematical problems. It is hoped that, through this module, students can improve their creative thinking skills and, more broadly, become better equipped to meet the demands of work and life in this digital era.

Meanwhile, in this research, the problem formulations proposed are 1) To what extent have the validity and practicality of the integration technique module for integral calculus learning been developed?; and 2) Is the integration technique module on integral calculus learning developed effective in improving students' mathematical creative thinking skills? The objectives of this research are 1) To determine the validity and practicality of the developed module of integration technique in integral calculus learning; and 2) To find out whether the module of integration technique in integral calculus learning developed is effective in improving students' mathematical creative thinking ability.

METHOD

The research is a type of development research that aims to produce a product and test its effectiveness in education, as Sugiyono (2015) described. The product developed in this research is an integral calculus module focusing on integration techniques with partial fractions. The development process of this module follows the ADDIE model and includes the stages of Analysis, Design, Development, Implementation, and Evaluation (Pribadi, 2009).

Participants

This research was conducted at the Mathematics Education Study Programme, Riau University, involving 16 third-semester students as research subjects. The sampling technique used was purposive sampling, where subjects were selected based on specific criteria relevant to the study's objectives.

Research Design and Procedures

Data were collected using a one-shot case study design, a one-time data collection approach during the research process. The step-by-step process of this research includes the following stages: (1) Analysis**:** an in-depth analysis of the existing curriculum, student needs, and learning materials was conducted; (2) Design**:** the module's specifications were determined based on the analysis results, including the module title, selection of integration technique material, and module format; (3) Development**:** the physical realization of the module was carried out based on the predetermined design. Two expert validators assessed the module and provided feedback for improvements; (4) Implementation: the developed module was tested by administering pretests and posttests to measure students' mathematical creative thinking skills and conducting limited trials in real settings; (5) Evaluation: The results from the module implementation were analyzed, including assessing the practicality and effectiveness based on student feedback and comparing pretest and posttest scores. Additionally, the module was further tested in a limited trial involving college students to evaluate its effectiveness in a real classroom setting. Pretest and posttest were administered to measure imrovements in students' mathematical creative thinking skills. The research was conducted over a period of one semester.

Instruments

The instruments used in this study included both test and non-test instruments. First, expert validation questionnaire: to assess the validity of the module. This questionnaire was adapted from the validation criteria developed by Subekti & Akhsani (2020). The questionnaire included 19 items covering various aspects of the module,

such as content accuracy, relevance, instructional design, and physical appearance. Each item was rated on a four-point Likert scale. The aspects and specific items evaluated were as follows: (1) Content: accuracy, systematic presentation, clarity, alignment with student ability, and supporting exercises; (2) Learning: student-centeredness, participatory nature, and interactivity; (3) Mathematical Creative Thinking Skills: support for achieving creative thinking skills through procedures and exercises; (4) Physical Appearance: attractive cover, readable font, and consistent font size and style; (5) Language: clear sentence structure, communicative language, and adherence to EYD (Indonesian Language Standard); (6) Layout: consistent, harmonious layout, and attractive composition and color selection.

Second, student response questionnaire: to measure the practicality of the developed module, adapted from Akbar (2017). The questionnaire consisted of 10 items divided into three main aspects: presentation, content, and language. Each item was rated on a four-point Likert scale. The aspects evaluated included the attractiveness and readability of the module, the clarity and relevance of the content, and the coherence and comprehensibility of the language used.

Third, mathematical creative thinking ability test: consisting of pretest and posttest questions designed to evaluate students' mathematical creative thinking skills. The test included 3 items covering three indicators: fluency, flexibility, and originality. The indicators and corresponding test items were as follows: (1) Originality: ability to determine the results of integration using trigonometric substitution based on a self-created function; (2) Fluency: ability to understand and apply the concept of rational function integrals with determining possible unknown values from the form of rational function integrals; (3) Flexibility: ability to determine the results of integration using various techniques.

The test items were validated for content and construct validity by experts in mathematics education. After the items were declared valid by the validators, the questions were subsequently tested on 32 students. The results of the test item trials indicated that the items were valid. The reliability of the instruments was determined using Cronbach's Alpha, resulting in a reliability coefficient of 0.85 for the student response questionnaire and 0.72 for the mathematical creative thinking ability test.

Data Analysis

Data collected included expert instrument validity scores, student response scores, and pretest and posttest scores for mathematical creative thinking skills. The data was analyzed using both quantitative and qualitative descriptive methods. Validation analysis involved calculating the average scores of various aspects of the module to assess its effectiveness in improving mathematical creative thinking skills. These scores were categorized based on the validity criteria developed by Subekti & Akhsani (2020).

Table 1. Module validity criteria

Score	Category
$1.00 \leq \bar{x} \leq 1.75$	Less Valid
$1.75 < \bar{x} \leq 2.50$	Moderately Valid
$2.50 < \bar{x} \leq 3.25$	Valid
$3.25 < \bar{x} \leq 4.00$	Very Valid

To measure the practicality of the module, the scores obtained through the student response questionnaire were converted into percentages. The resulting percentage was then categorized according to the predetermined practicality criteria in the following table (Akbar, 2017).

Table 2. Module practicality criteria

No	Practicality Percentage	Practicality Level
1	$0 \leq p \leq 20$	Very impractical
2	$20 < p \leq 40$	Not practical
3	$40 < p \leq 60$	Less practical
4	$60 < p \leq 80$	Practical
5	$80 < p \leq 100$	Very Practical

The module's effectiveness was evaluated based on improving mathematical creative thinking ability. This evaluation measured the scores before and after using the module. The n-gain was used to calculate the ability improvement. After calculating the n-gain, students' n-gain levels were classified based on certain criteria to determine how high the improvement was achieved.

Table 3. Student mathematical creative thinking ability n-gain criteria

Magnitude of N-Gain (g)	Interpretation
$g < 0.3$	Low
$0{,}3 \leq g < 0.7$	Medium
$g \geq 0.7$	High

The qualitative descriptive analysis focused on examining the feedback provided by students and experts during the validation and implementation stages. This analysis involved categorizing and summarizing the qualitative data to identify common themes and insights regarding the module's usability, clarity, and overall effectiveness. Student feedback was particularly important in understanding how the module facilitated their learning process and what improvements could be made. Expert feedback helped refine the module content and structure to ensure it met educational standards and effectively addressed the learning objectives.

■ RESULT AND DISCUSSION

Analyze

Data were collected using a one-shot case study design. An in-depth analysis of the existing curriculum, student needs, and learning materials was conducted. The needs analysis identified that integration techniques with partial fractions are particularly challenging for students. The analysis involved collecting input from lecturers and students, revealing a significant difficulty in understanding and applying these techniques. The total number of participants in the needs analysis was 33 people.

Table 4. Needs analysis results

Issue Identified	Frequency of Mention
Difficulty with partial fractions	82%
Need for multiple problem-solving methods	73%
Lack of conceptual understanding	64%

The high frequency of mention (85%) regarding difficulties with partial fractions indicates a prevalent issue among students. This aligns with research by Supiadi, Sulistyo, Rahmani, Riztya, & Gunawan (2023), which suggests that multi-step mathematical processes often pose significant challenges due to the complexity involved. The difficulty in determining various problem-solving methods further underscores the need for instructional materials that promote creative thinking and flexibility in approach. This problem can be attributed to the abstract nature of partial fractions and the lack of adequate foundational skills in algebra and calculus among students.

To address these issues, our module focuses on providing clear, step-by-step instructions and multiple examples to illustrate different problem-solving methods. By incorporating these elements, we aim to improve students' comprehension and application of the technique. Furthermore, integrating exercises that require students to explore various solution paths can enhance their creative thinking skills. This is crucial, as creative problem-solving abilities are essential for success in higher-level mathematics and related fields.

Our findings are consistent with those of Saidah, Dwijanto, & J, (2020), who emphasize the importance of targeted instructional strategies in overcoming learning obstacles in complex topics. While their research focused on general strategies, our study adds a specific focus on partial fractions, providing a more targeted approach. This alignment suggests that our module could be a valuable addition to existing educational practices, offering a specialized tool for addressing common difficulties in integral calculus.

Design

The design phase involved determining the module's specifications based on the analysis results, including the module title, selection of integration technique material, and module format. Concept maps were developed to illustrate the structure of the material and the relationships between concepts in integration techniques. These concept maps were foundational in arranging the content logically and coherently.

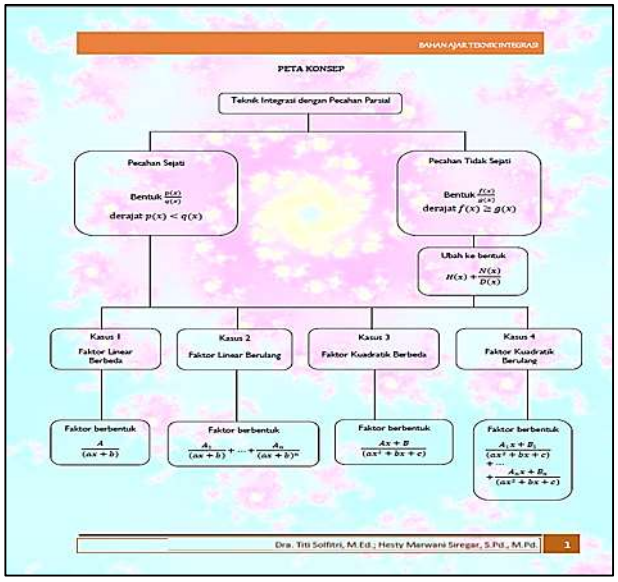

Figure 1. Concept map of integration technique with partial fractions

Concept maps help students visualize and understand the connections between different mathematical concepts. As stated by Hartsell (2021), concept maps help students organise and visually present information and highlight key points that direct their attention. By structuring the material using concept maps, we ensure that students can see how individual topics fit into the larger framework, facilitating a more integrated understanding of integration techniques.

The use of concept maps also allows students to see the broader applications of each concept, linking abstract mathematical ideas to practical problems. This visual approach caters to different learning styles, particularly benefiting visual learners who might struggle with traditional text-based instruction. Moreover, concept maps can serve as a useful revision tool, helping students quickly recall and connect various concepts during exam preparation.

Our approach is similar to methods used in other fields, such as science education, where visual aids are commonly employed to illustrate complex relationships (Sawyer, 2022). The use of concept maps in mathematics education adds a visual and structured element that aids in comprehension and retention, consistent with findings in other disciplines. However, our study goes further by integrating these maps directly into the learning module, making them an integral part of the instructional strategy rather than supplementary aids.

Development

The physical realization of the module was carried out based on the predetermined design. The module was created with detailed instructions, varied examples, and practice problems. Two expert validators assessed the module and provided feedback for improvements. The validation results showed that the average validation score was 3.67, placing the module in the "very valid" criteria. This score indicates that the module has been designed well and by the pedagogical needs and substance of the expected material. This step is crucial in ensuring the module's readiness for practical application, providing a strong foundation for effective learning. The validation process involved rigorous reviews by experts who assessed the clarity, relevance, and depth of the content, ensuring that it aligns with current educational standards and best practices. By receiving feedback from both material and pedagogy experts, we ensured that the module is not only accurate in terms of content but also effective in terms of teaching methodology. This dual validation approach helps address potential gaps that might arise if only one type of expert were consulted. The feedback received during validation was instrumental in refining the module, making necessary adjustments to improve clarity and engagement.

Our validation process aligns with standard educational practices, as emphasized by Hattie & Zierer (2018). The rigorous validation by experts ensures that the module is both academically sound and pedagogically effective, similar to validation processes used in other successful educational materials. Our validation scores are notably high, suggesting that the module is well-prepared for implementation in various educational settings. One example of how the material and example problems presented in the module, which are solved using more than one way, can be seen in the following figures.

Implementation

After the module was improved according to the validator's suggestions, it was then implemented in a small class. Students' feedback collected through interviews during implementation provided additional insights into the module's practicality. One student mentioned, "The step-by-step instructions were really helpful, especially for understanding the more complex

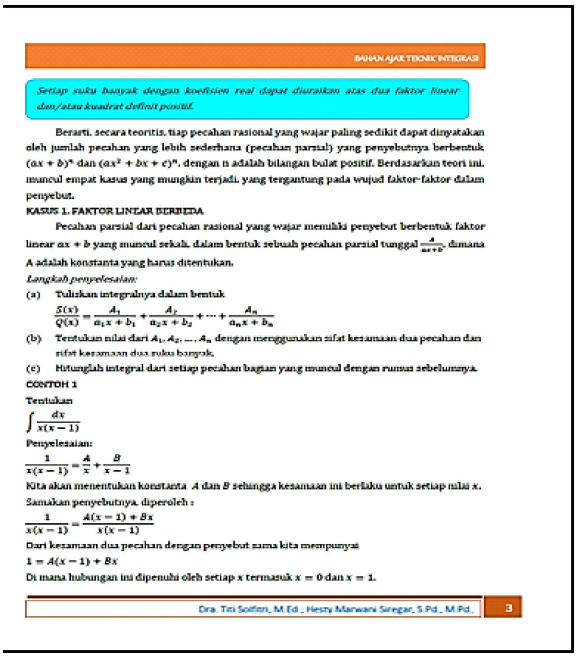

Figure 2. Example of material presentation in the module

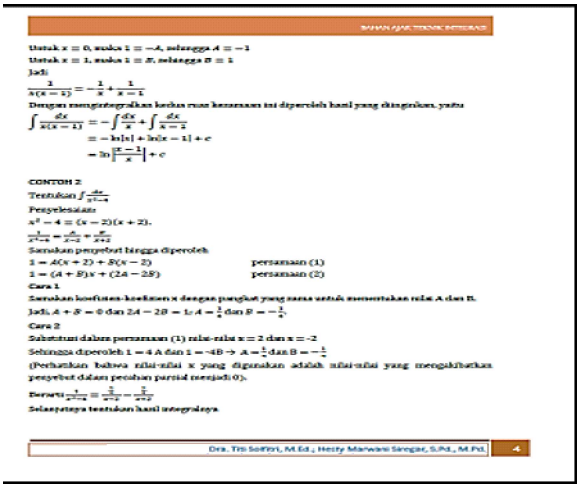

Figure 3. One example of a problem in the module

problems." Another student highlighted, "Having multiple examples really helped me see different ways to solve the problems." After this implementation, a practicality test was conducted. To measure the practicality of the developed module, a student response questionnaire was adapted from Akbar (2017). The questionnaire consisted of 10 items divided into three main aspects: presentation, content, and language. Each item was rated on a four-point Likert scale. The statements in the questionnaire assessed whether the module is considered interesting, which contributes to a positive impression and an increase in students' enthusiasm for learning. The questionnaire also measured the readability of the module through font shape and size, which is important for visual comfort during learning. Additionally, it assessed the clarity of the language used in the module, which should be clear, coherent, and easy to understand to facilitate a better understanding of the content presented.

The practicality test also assessed whether students' learning experience was enriched through the module and whether students did not feel burdened, indicating that the workload had been adjusted to their needs and capacity. From the test results, it was found that the average percentage of module practicality was 51.6, which is equivalent to 81% on a percentage scale. Six of the proposed assessment items made it to the "very practical" category, indicating a high level of practicality in certain aspects. The other four assessment items fell into the "practical" category, indicating significant benefits but still room for improvement.

The high practicality scores indicate that students found the module useful and easy to use. This feedback is vital for confirming that the module not only meets academic standards but is also engaging and accessible for students, which is essential for effective learning. The positive responses across various aspects, such as readability and convenience, suggest that the module is well-designed to meet students' needs.

According to Hattie & Zierer (2018), the practicality of teaching materials plays a key role in learning success, as good teaching materials should be used easily by students to achieve the desired learning outcomes. The high practicality scores suggest that the module can significantly

enhance learning experiences, consistent with findings from similar educational interventions. Unlike some previous studies that focused primarily on content delivery, our study emphasizes the practical usability of the module, making it a comprehensive tool for both instruction and learning. This comprehensive implementation approach ensures that the module not only adheres to high academic standards but also addresses the practical needs of students, ultimately aiming to improve their learning outcomes in integral calculus and related mathematical fields.

Evaluation

The results from the module implementation were analyzed, including assessing the effectiveness based on student feedback and comparing pretest and posttest scores. The pretest and posttest of the mathematical creative thinking ability test were conducted on 16 subjects of the limited trial. This improvement reflects the module's success in improving the understanding of mathematical concepts and encouraging students to apply their knowledge in more creative and productive ways. This success is expected to positively contribute to learning mathematics as a whole and promote the development of similar teaching materials that can be applied in other educational contexts. The pretest and posttest results can be seen in the following figure.

The significant increase in test scores demonstrates the module's effectiveness in

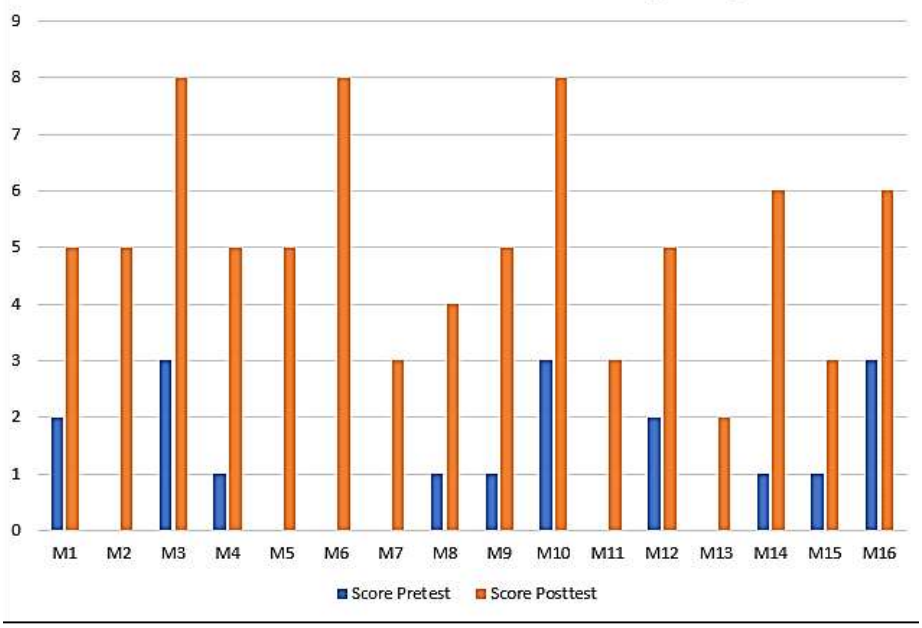

Figure 4. Achievement of mathematical creative thinking ability score

enhancing students' creative thinking abilities. The average n-gain score of 0.59 falls into the moderate category, indicating substantial improvement. This improvement reflects the module's success in fostering creative problem-solving skills, a critical aspect of mathematical education.

The significant increase in pretest and posttest scores indicates that the module effectively improves students' mathematical creative thinking skills. These results align with research by Saidah, Dwijanto, & J (2020), revealed that learning strategies that focus on developing creative thinking skills can provide

significant benefits to understanding in learning mathematics. This module helps students understand integration techniques with partial fractions and encourages them to apply their knowledge more innovatively and productively. In mathematics education, thinking creatively and finding diverse solutions is essential.

The improvement in students' scores can be attributed to the module's structured approach, which emphasizes understanding and application rather than rote learning. By providing varied examples and encouraging multiple solution paths, the module helps students develop flexible thinking skills. These skills are essential for tackling complex mathematical problems and are highly valued in both academic andprofessional contexts.

The findings of this study clearly demonstrate the successful development and implementation of the integration technique module for integral calculus learning in terms of both validity and practicality. The module received an average validation score of 3.67 from expert validators, placing it in the "very valid" category, indicating that the content is both accurate and pedagogically sound. The practicality of the module, assessed through student questionnaires, resulted in high scores across presentation, content, and language aspects, with an overall average percentage of 81%. This confirms that the module is user-friendly, engaging, and well-received by students, addressing their needs effectively.

Moreover, the effectiveness of the module in enhancing students' mathematical creative thinking skills was evident from the significant improvement in pretest and posttest scores. The average n-gain score of 0.59, categorized as moderate, highlights the substantial positive impact of the module on students' ability to think creatively and solve problems. This improvement aligns with the research objectives, proving that the module not only meets standards of validity and practicality but also significantly enhances mathematical creative thinking skills. These results underscore the module's potential as a valuable educational tool, capable of addressing common learning challenges in integral calculus and fostering greater creative thinking abilities among students.

Our findings are consistent with research by (Supiadi, Sulistyo, Rahmani, Riztya, & Gunawan, 2023; Setiyani et al., 2022; Purwaningrum et al., 2021; Asri et al., 2019), which highlights the positive impact of modules designed to enhance creative thinking. However, our module's unique approach of using detailed concept maps and varied examples offers an innovative enhancement that further promotes creative thinking skills, setting our study apart from previous research. Our study also provides a more focused application in the context of integral calculus, offering specific insights into how such modules can be effectively implemented in mathematics education.

Although the results of this study show that the module is effective, there is still room for improvement. The evaluation that showed several items in the "practical" category indicates that although the module is good, certain aspects can still be improved. Continuous evaluation and user feedback are key to developing effective teaching materials. Researchers can continue to improve this module by considering feedback from students and lecturers and adding more examples of varied and challenging problems.

The development of learning modules like this has broader implications in the educational context. A well-designed module based on in-depth needs analysis can be applied in various other fields of study for topics that students find difficult. Sawyer (2022) emphasizes the importance of adaptive learning design responsive to student needs to improve the overall quality of education. Adaptive learning design can be supported using modules that meet students' needs. In general, it can be said that the developed module can facilitate students' mathematical creative thinking skills in integral calculus courses.

CONCLUSION

The results of this study show that the integration technique learning module designed through the ADDIE approach can significantly improve students' mathematical creative thinking skills. The module, which focuses on integration techniques with partial fractions, successfully fulfills the learning needs identified from the initial analysis and feedback from lecturers and students. The validity and practicality of the module were tested and confirmed through expert evaluation and student responses, which rated the module as "very valid" and "very practical". The practicality evaluation showed that the module has good language clarity, readability, and ease of understanding and provides appropriate challenges to develop students' mathematical creative thinking skills. In addition, the increase in students' pretest and posttest scores shows that this module is effective in helping students master integration techniques and apply them in creative and innovative ways.

Based on the results of this study, several suggestions can be made. First, lecturers who teach integral calculus courses should use this module as one of the teaching materials. This module has been proven effective in improving students' mathematical creative thinking skills, so it can help in achieving more comprehensive learning objectives. In addition, lecturers are also expected to continue to adapt and develop this module by adding more examples of varied and challenging problems and adjusting the module content per curriculum developments and student needs.

Secondly, this research shows the importance of validation and evaluation processes in developing learning modules for other teaching material developers. Validation by experts and user feedback is essential to ensure that the developed module is academically accurate, practical, and effective in the learning context. Developers of teaching materials should consider the ADDIE approach or other systematic development methods to produce quality products that meet user needs.

Third, educational institutions are recommended to support and facilitate the development of innovative teaching materials that can improve the quality of learning. Investment in the development of teaching materials based on needs analysis and empirical research can significantly impact student learning outcomes. Institutions can also organize training and workshops for lecturers to introduce innovative teaching techniques and methods, including using learning modules developed in this study.

This study shows that systematically designed and needs-based learning modules can significantly improve students' mathematical creative thinking skills. Thus, developing innovative and effective teaching materials should be prioritized to enhance the quality of education in this digital era.

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