

## ANALYSIS OF THE IMPACT OF ARTIFICIAL INTELLIGENCE (AI) TECHNOLOGY IMPLEMENTATION IN INTEGRAL CALCULUS LEARNING

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Received 28 November 2024; Received in revised form 01 September 2025; Accepted 06 September 2025

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### ABSTRACT

Artificial Intelligence (AI) in the era of Society 5.0 processes big data to facilitate various human needs. Its implementation can now be found in various sectors, including the learning process, where the use of AI technology is frequently applied. In this 21st century, technological advancement, especially in the field of education, is something we can no longer avoid. With such advancements, educators are required to be able to utilize and operate technology in line with its development. Educators must be capable of providing instruction to students so that they can master various subjects, particularly mathematics, which is known to have a high level of difficulty. The AI applications used in this research are intelligent chatbot-based applications powered by Machine Learning, such as ChatGPT, PhotoMath, Gauth Math, and others. The purpose of this study is to determine the impact of using AI technology in mathematics learning, particularly in the Integral Calculus course. The type of research used in this study is descriptive research with a qualitative approach. The techniques used to obtain data in this study are written tests and in-depth interview techniques. The subjects in this study were two students selected to represent how AI is used in solving the given tests. The results of the study show that Subject IM used AI applications as a tool to help recall previously learned material and/or to recheck the answers to their work. Subject NR used AI applications as a tool to help recall previously learned material or to provide guidance for solving problems they did not yet understand. Overall, the impact of using AI in learning integral calculus is that it helps students to learn independently in solving problems they do not understand how to solve.

**Keywords:** artificial intelligence, integral calculus, technology.

### ABSTRAK

*Artificial intelligence (AI) pada era Society 5.0 mengolah big data untuk memfasilitasi berbagai kebutuhan manusia. Implementasinya kini telah ada di berbagai sektor. Tidak terkecuali dalam proses pembelajaran, penggunaan teknologi AI pun sering digunakan. Di abad 21 sekarang ini kemajuan teknologi khususnya dibidang pendidikan tidak dapat kita hindari. Dengan kemajuan itu pendidik wajib untuk dapat memanfaatkan dan mengoperasikan teknologi dalam perkembangannya. Pendidik harus mampu memberikan pengajaran kepada peserta didik agar dapat menguasai berbagai mata pelajaran khususnya matematika yang penuh dengan tingkat kesulitan yang tinggi. Adapun aplikasi AI yang digunakan dalam penelitian ini adalah aplikasi chatbot cerdas berbasis Machine Learning seperti ChatGPT, PhotoMath, Gauth Math. Tujuan dari penelitian ini adalah untuk mengetahui bagaimana dampak dari penggunaan teknologi AI dalam pembelajaran matematika khususnya pada matakuliah Kalkulus Integral. Jenis penelitian yang di gunakan dalam penelitian ini adalah penelitian deskriptif dengan pendekatan kualitatif. Teknik yang dilakukan untuk memperoleh data dalam penelitian ini adalah tes tertulis, dan teknik wawancara mendalam (In dept interview). Subjek dalam penelitian ini dipilih dua orang mahasiswa yang dapat mewakili cara penggunaan AI dalam menyelesaikan tes yang diberikan. Hasil penelitian menunjukkan bahwa Subjek IM menggunakan aplikasi AI sebagai sarana untuk membantu mengingat kembali materi yang sudah dipelajari dan atau mengecek kembali jawaban hasil pekerjaannya. Subjek NR menggunakan aplikasi AI sebagai sarana untuk membantu*

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*mengingat kembali materi yang sudah dipelajari atau memberikan panduan untuk penyelesaian soal yang belum dipahaminya. Secara keseluruhan dampak penggunaan AI dalam pembelajaran kalkulus integral adalah membantu mahasiswa untuk belajar secara mandiri dalam menyelesaikan soal yang mereka tidak mengerti cara penyelesaiannya.*

**Kata kunci:** *artificial intelligence, kalkulus integral, teknologi.*



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## Introduction

The teaching and learning process employs one of its instructional techniques through the use of various learning media (Sabella et al., 2023). Along with the rapid advancement of technology, particularly artificial intelligence (AI), the field of education has also undergone significant transformation. According to Sinaga (2024), the utilization of this technology not only alters the way information is delivered but also opens new opportunities for more interactive and adaptive learning processes. Therefore, it is important to examine more deeply how the application of AI technology impacts teaching and learning, especially in courses that demand conceptual understanding and problem-solving skills such as Integral Calculus (Ishartono et al., 2024). Gil and Luton (2009) in their research explained that mathematics learning can be viewed as the effort of teachers, lecturers, and trainers in assisting students, university students, and trainees to understand or master mathematics. Since teachers aim to help students learn mathematics, they must understand the actual pathways or processes through which mathematics can be comprehended or mastered by students (Harnawati & Hidayati, 2024). Otherwise, it would certainly be difficult for teachers to assist their students in learning mathematics (Auna & Hamzah, 2024).

The progression of time in human life is an inevitability. In the current era of globalization, technology has developed rapidly and has become increasingly sophisticated (Permatasari & Yuniarta, 2021). In the era of the Industrial Revolution 4.0, humans were enabled to access and simultaneously share information via the internet. Entering the 5.0 era, technology has become an integral part of human life (Sari & Donna, 2023). Maharani (2020) explained that its implementation has now permeated various sectors, including education, where the use of AI technology is increasingly prevalent. In the Industrial 4.0 era, the focus of AI in mathematics learning was directed towards the efficiency of learning processes and the automation of educational systems, whereas in the Society 5.0 era, the use of AI in mathematics learning is more human-centered, meaning that AI is utilized to enhance the quality of learning and provide personalized support to students (Jan Setiawan et al., 2024). This aligns with the statement of Kaluge (2024), who emphasized that, alongside the progress of science and technology, which has become the focal point of global attention, humans need to create advanced technological tools.

In the 21st century, technological advancement, particularly in the field of education, is unavoidable (Meiliawati et al., 2024). With these advancements, educators are required to utilize and operate technology in line with its development (Shodiqin et al., 2024). This is consistent with Mahendra (2024), who stated that educators must remain updated with technological progress. Educators

should be able to provide instruction that enables learners to master various subjects, especially mathematics, which is characterized by high levels of difficulty (Ardiansyah et al., 2022). According to Turban, as time evolves, educational media technologies continue to improve. One of these is learning media based on Artificial Intelligence. The process of preparing or designing a machine such as a computer to have human-like properties or behavior is referred to as Artificial Intelligence. The ultimate goal of Artificial Intelligence is to enable computers to be instructed as humans are (Sabella et al., 2023). However, as noted by Meldi (2022), there is concern that technology is inevitably prone to misuse, as the majority of users tend to employ technology in learning merely to simplify tasks, without grasping the meaningfulness, concepts, or cognitive thinking in mathematics.

Nevertheless, disparities exist in the use of Artificial Intelligence (AI) in mathematics learning. Based on the observations of the research team during teaching activities in the Mathematics Education Study Program at FKIP UNTAD, it was found that many students still utilize AI technology merely to complete assignments or simply to answer lecturers' questions. Yet according to Arditya Prayogi (2024), the use of AI technology can extend beyond such purposes. AI in learning can serve as a tool for finding references, as a medium for independent study, as a means of comparison, and more.

According to Sudipa (2023), AI is more appropriately functioned as a device that assists human activities in all aspects, rather than serving as an absolute substitute for human roles. Technological development can be observed through the evolution of Artificial Intelligence (AI), which increasingly facilitates all aspects of life, including education (Hanan & Sugiman, 2025). Gara Yusvano (2024) also argued that the growth of artificial intelligence in the present era has to some extent influenced every aspect of life within families, schools, and society. In line with this, Siregar (2024) asserted that technological advancement, particularly AI, has opened new opportunities to enhance the quality of learning, including in the field of mathematics. Similarly, Silvana Samaray (2024) emphasized that the use of AI technology is becoming increasingly widespread across various fields, including the education sector.

The mathematics material provided to first-year university students generally begins with Calculus, as it encompasses numerous applications across multiple fields. This is not limited to mathematics education, where prospective teachers are expected to teach Calculus concepts at the senior high school level, but also serves as a foundation for advanced analytical courses (Muttaqin & Yahya, 2023). Calculus is often perceived as one of the most intimidating courses due to the lengthy and complex calculations required to solve problems. This fact is reflected in the abundance of studies that attempt to improve students' comprehension of integral calculus through the use of applications, including animations and computational tools (Meldi et al., 2022).

Based on the aforementioned facts and descriptions, understanding the impact of AI usage in learning is crucial so that lecturers and other educators can design effective learning processes with AI as a learning medium, enabling students and learners to absorb instructional content more effectively. This is what motivates the researchers to investigate the impact of AI technology implementation in mathematics learning, particularly in the Integral Calculus course.

This study aims to identify the impact of Artificial Intelligence (AI) technologies or applications in mathematics learning, specifically in the Integral Calculus course. The fundamental contribution of this study is expected to serve as a reference for educators (lecturers, teachers, and other instructors) in designing learning strategies that utilize AI technology. It is also anticipated that AI will be employed appropriately in learning, given that its use is inevitable amid current technological development. Furthermore, according to Nurwahid (2024), AI can be utilized to design more effective teaching methods through the analysis of students' learning needs, the provision of material recommendations that align with their level of understanding, and the delivery of rapid and adaptive automated feedback. Yusuf (2024) further stated that AI enables the development of more personalized learning systems, whereby teaching strategies are no longer unidirectional but can be adapted to the learning styles, pace, and varying levels of difficulty among learners.

### **Research Methods**

This study employs a qualitative research design with a descriptive method. The purpose of this research is to describe the impact arising from the use of AI technology in integral calculus learning. The focus of this research is to analyze the effects generated by the use of AI in the teaching and learning of Integral Calculus.

To obtain data aligned with the research focus, several instruments were utilized. The primary instrument in this study was the researcher. In addition to the main instrument, supporting instruments were also employed, namely: (1) an integral calculus test, and (2) an interview guide. To ensure the quality of the instruments, a validation process was conducted, covering both content validity and reliability. Content validity was established through expert judgment by lecturers specializing in calculus and qualitative research methodology in mathematics education. Furthermore, the test instrument and interview guide also underwent a limited trial with a small group of respondents before being used in the main study.

The integral calculus test in this study was used to measure students' ability to utilize various Artificial Intelligence (AI) applications to solve integral problems. Through this test, students were provided with a set of diverse integral problems. They were then instructed to attempt using AI applications as tools to assist in solving the problems. From this process, the researcher was able to assess the extent to which students understood integral concepts, while also observing how well they employed AI technology in an accurate, critical, and effective manner. Meanwhile, the interview guide was used to gather more in-depth qualitative data concerning students' experiences, perceptions, and challenges in utilizing AI technology.

The research subjects were determined based on the analysis of students' responses to the integral calculus test. From this analysis, two subjects were identified as demonstrating the impact of AI technology usage.

### **Results and Discussion**

#### *Research Findings*

In this section, the research findings on the impact of implementing Artificial Intelligence (AI) technology in integral calculus learning are presented. Based on descriptive qualitative analysis, the study shows that the use of AI enhances

students' understanding of integral calculus material and creates a more interactive and adaptive learning experience. The research subjects were determined based on the analysis of students' responses to the integral calculus problem test. From this analysis, two students were identified as subjects who demonstrated the impact of AI technology usage. The following describes the steps for selecting the research subjects.

- 1) The researcher administered an integral calculus problem test to mathematics education students consisting of four questions. The researcher instructed that the problems could be solved using AI applications commonly used by the students. Each step of the solution had to be written clearly and accompanied by information on which AI application was used to assist in solving the problems.
- 2) The researcher analyzed the results of the integral calculus problem test.
- 3) The researcher grouped the potential research subjects based on their performance and the number of AI applications used in solving the test. The grouping of subjects is shown in Table 1.

Table 1. Analysis of integral calculus test results

<b>Number of Students</b>	<b>Test Score</b>	<b>Number of AI Applications Used</b>
5	100	3 applications
4	100	2 applications

- 4) Since more than one candidate met the criteria, the subjects were selected based on the consideration of the integral calculus course lecturer. Thus, two students were designated as research subjects: IM, who used two AI applications, and NR, who used three AI applications. Both students obtained a perfect score of 100 on the integral calculus problem test.

After selecting the qualified research subjects, the researcher conducted data verification through in-depth interviews with both students. This aimed to obtain data on the impact of AI usage in mathematics learning, particularly in the integral calculus course.

1. *After selecting the qualified research subjects, the researcher conducted data verification through in-depth interviews with both students. This aimed to obtain data on the impact of AI usage in mathematics learning, particularly in the integral calculus course.*

The data from the test results completed by subject IM are shown in Figure 1.

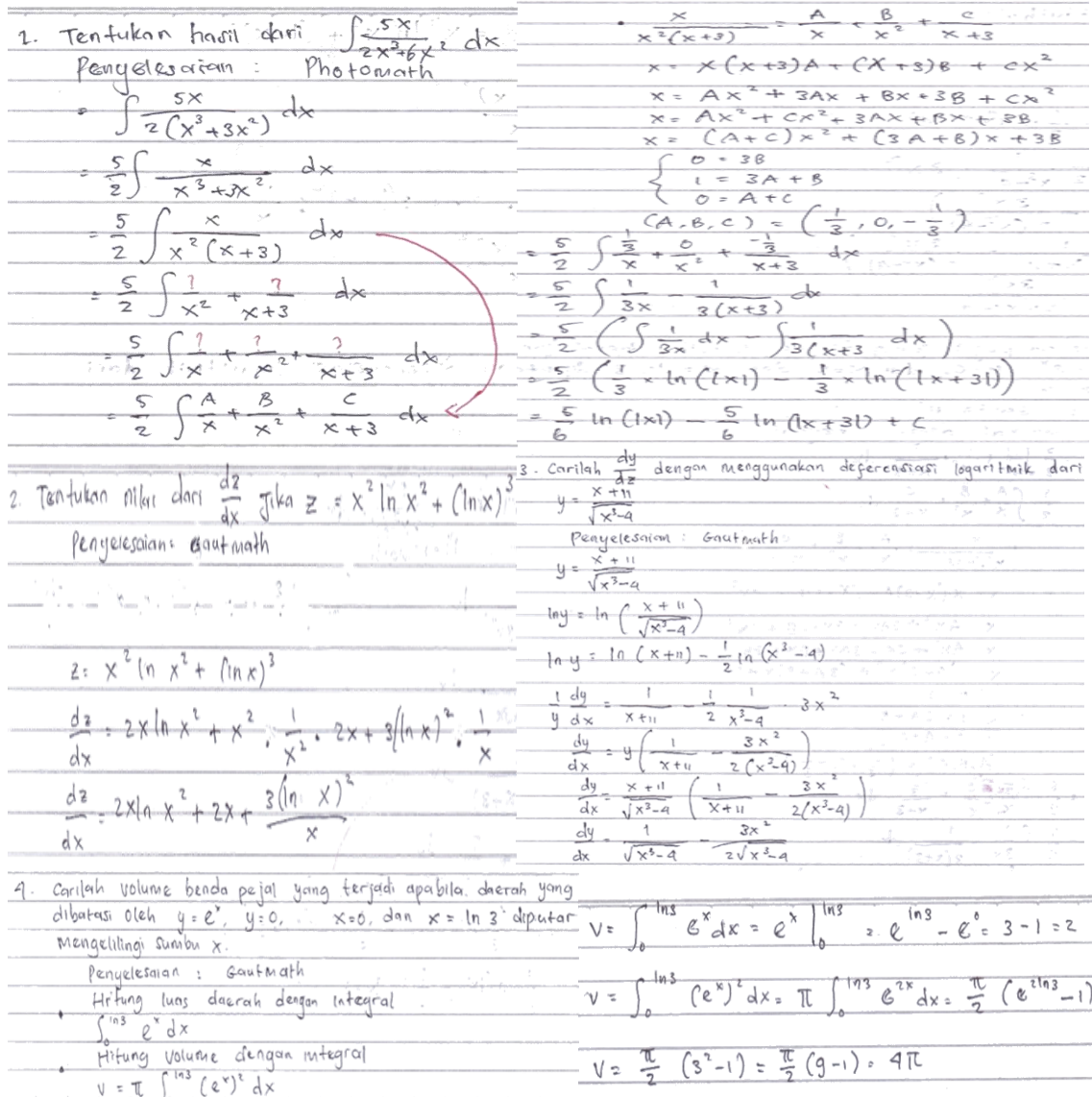


Figure 1. Integral calculus test results of subject IM

Based on the test results in Figure 1 and the in-depth interview conducted, the following findings were obtained:

- 1) Subject IM used two different AI applications in solving the given integral calculus problems (IM-004, IM-009, IM-013, IM-017).
  - 2) Subject IM verified the answers generated by AI applications by cross-checking them with their own knowledge (IM-006, IM-011, IM-015, IM-021).
  - 3) Subject IM frequently used AI applications to solve mathematical problems (IM-022).
  - 4) Subject IM employed AI applications as tools to recall previously learned material and/or to recheck the accuracy of their own solutions (IM-023).
2. *Data presentation and interview results from subject NR, who used three AI applications to solve the integral calculus problem test*  
 The data from the test results completed by subject NR are shown in Figure 2.

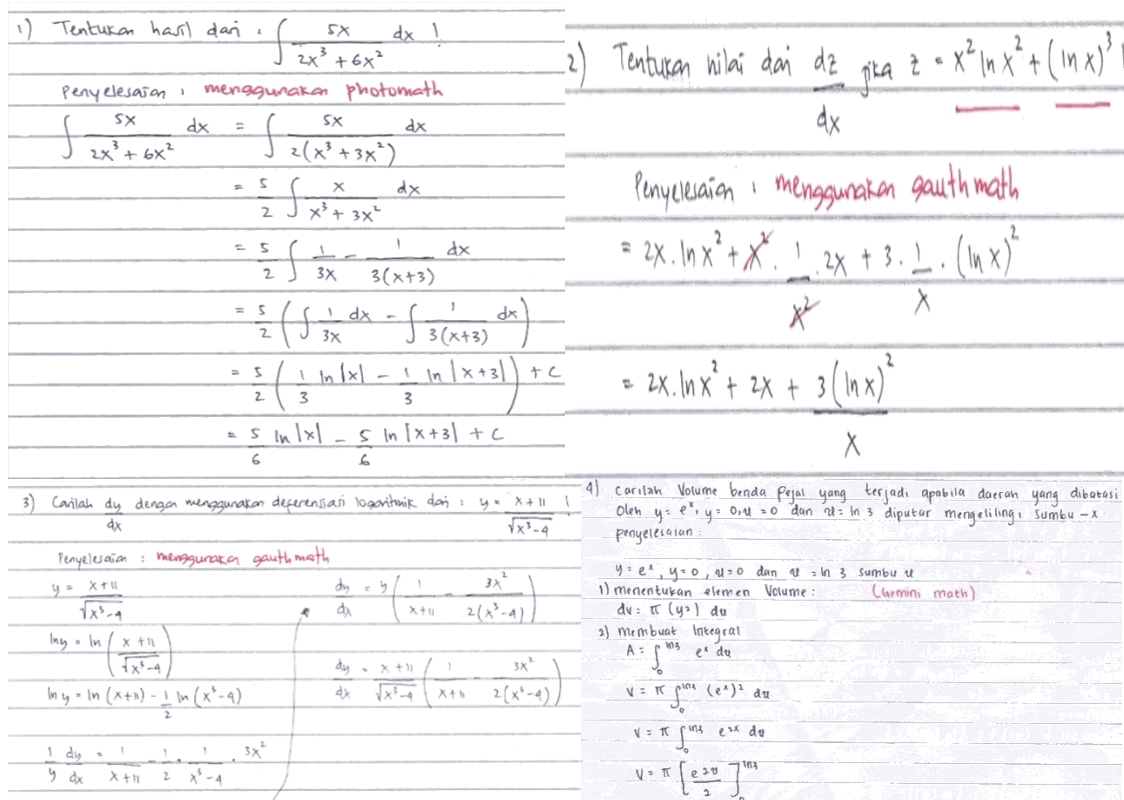


Figure 2. Integral calculus test results of subject NR

Based on the test results in Figure 2 and the in-depth interview conducted, the following findings were obtained:

- 1) Subject NR used three different AI applications in solving the given integral calculus problems (NR-005, NR-009, NR-013, NR-017).
- 2) Subject NR reviewed the answers generated by AI applications by carefully examining the solution steps provided. If NR did not understand the solution from one application, they sought alternative solutions from other applications (NR-007, NR-010, NR-011, NR-012, NR-015, NR-019, NR-020).
- 3) Subject NR frequently used AI applications to solve mathematical problems (NR-022).
- 4) Subject NR employed AI applications as tools to recall previously learned material or as guidance for solving problems that were not yet understood (NR-023).

#### Analysis and Discussion

Subjects IM and NR both used several AI applications, such as Photomath, Gauthmath, and Gemini Math, to help solve integral calculus problems. The use of these applications facilitated their understanding of solution steps that were otherwise difficult to recall. Both demonstrated a tendency to verify the AI-generated answers with the knowledge they had acquired in class, indicating that they were not merely copying solutions but also striving to comprehend the processes involved.

Both IM and NR employed different applications depending on the type of problem. IM tended to prefer Gauthmath over Photomath when the problem was presented in a word format, whereas NR used Gemini Math when the other

applications were less helpful in providing easily understood solutions. This shows that students adapted their choice of AI applications based on the type and complexity of the problems, as well as the clarity of the solutions offered by each application.

AI has proven to be an effective tool in assisting students with solving complex mathematical problems such as integral calculus. Both IM and NR used AI not only to obtain solutions but also to reinforce their understanding of correct solution steps. This indicates that AI can function as an additional tutor, helping students overcome difficulties in learning mathematics, particularly on complex topics.

Although AI assists students in problem-solving, it is important to note that both IM and NR consistently re-examined the AI-generated answers against their own knowledge. This demonstrates that while AI is helpful, it does not fully replace students' analytical abilities and critical judgment. Thus, AI serves as a supportive tool, while independent learning remains crucial for a deep understanding of the material.

The use of multiple AI applications by both subjects highlights the importance of flexibility in learning tools. Each application has strengths and weaknesses depending on the type of problem encountered. Therefore, integrating various AI technologies into learning can enrich students' learning experiences and provide them with multiple options to understand the material in ways that are most effective for them.

The use of AI by the subjects was not limited to problem-solving but also served as a self-assessment tool. Both IM and NR utilized AI to verify whether their solutions aligned with the taught steps. This means that AI supported them in the processes of reflection and self-correction, which are essential in learning mathematics. In other words, AI functioned as an evaluative tool that allowed students to assess their own level of understanding before submitting their final work.

Despite the benefits of AI, there are potential risks of dependency on such technology. In the interviews, both IM and NR admitted that they often relied on AI applications to answer problems they had forgotten how to solve or those that were too difficult to complete independently. This indicates that students may become inclined to rely more on technology rather than attempting to recall or solve problems without assistance. Such dependency may hinder the development of independent analytical skills if not accompanied by efforts to understand concepts more deeply beyond what the applications provide.

To mitigate this, several strategies can be implemented. First, instructors can integrate problem-based exercises that require students to solve problems without AI assistance, ensuring that their critical thinking and mathematical skills are independently honed. Second, assignments can be designed to challenge students to analyze solution steps before resorting to AI, so that they do not merely accept final answers but also understand the processes involved. Third, educators can emphasize the use of AI as a tool for reflection or verification rather than as the primary solution. Thus, the integration of AI in integral calculus learning can yield maximum benefits while maintaining students' independence in thinking and problem-solving abilities.

## Conclusion and Suggestion

This study demonstrates that the use of Artificial Intelligence (AI) technology in integral calculus learning has a positive impact on students' understanding and problem-solving skills. Based on interview and test results, subjects IM and NR utilized various AI applications such as Photomath, Gauthmath, and Gemini Math to assist them in solving integral calculus problems. The use of AI not only facilitated problem-solving but also helped students recall material that had been previously learned.

Although students frequently used AI as a supporting tool, they consistently reviewed and validated the answers provided by the applications. This indicates that AI functioned as a learning aid that helped students understand the solution steps, rather than merely providing automatic answers. Thus, AI can enhance students' comprehension of difficult mathematical concepts, particularly in topics such as integral calculus. However, there is a potential risk of dependency that must be carefully considered. Students who rely too heavily on AI may encounter difficulties in developing independent analytical skills if they do not make efforts to understand the concepts more deeply beyond what the applications provide.

Educators should guide students to use AI wisely. AI should be regarded as a learning aid rather than an instant solution. Students must be encouraged to consistently examine and comprehend the solution steps presented by AI, so that they continue to develop analytical skills and achieve a deeper understanding.

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