

Comparing Traditional Instructional Methods to ChatGPT: A Comprehensive Analysis

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Abstract— In today's educational landscape, shaped by rapid technological advancements, this study addresses the pertinent issue of inclusion of artificial intelligence (AI) in mathematics education. The focus is specifically on the utilization of ChatGPT, an AI-driven tool, to enhance the comprehension of differentiation and integration concepts among students. The contemporary educational context emphasizes the significance of AI in transforming learning experiences. However, the practical implications of AI implementation remain a subject of inquiry and exploration. This study seeks to bridge the gap between the potential of AI and its actual impact on learning outcomes. This research engages a comprehensive approach, involving both a survey and a subsequent post-test assessment. The survey phase aims to capture the viewpoints of students, regarding their preferences and experiences with traditional versus AI-driven problem-solving methods. Subsequently, the post-test evaluation seeks to measure the efficacy of ChatGPT. Participants found the AI tool particularly useful for clarifying complex concepts and providing immediate solutions. However, some students also expressed a preference for the personalized interaction and contextual explanations that human instructors offer. The findings suggest that while AI assistance has its merits, a balanced approach that integrates human expertise and AI support can potentially create a more comprehensive learning experience.

Keywords—ChatGPT, Artificial Intelligence, Differentiation, Integration

JEET Category— Practice

I. INTRODUCTION

In today's rapidly evolving educational landscape, the integration of advanced technologies has become essential to accommodate students various learning demands. One such disruptive technology ChatGPT, an advanced AI-driven chatbot created by OpenAI, has attracted a lot of interest. ChatGPT represents a remarkable stride in natural language processing and AI-powered assistance, with the potential to reshape the way students engage with intricate subjects like

mathematics. Traditional approaches to mathematics education have long relied on conventional teaching methods, encompassing textbooks, classroom lectures, and problem-solving exercises. While these methods form the bedrock of education, they sometimes lack the personalized and interactive elements that cater to diverse learning styles. Moreover, students often encounter challenges when grappling with abstract mathematical concepts such as differentiation and integration, which can hamper their enthusiasm and hinder academic progress (Lopez et al., 2023).

The advent of ChatGPT introduces a paradigm shift in mathematics education. This AI-powered chatbot offers step-by-step explanations, responds to queries, and aids in problem-solving through natural language interactions (Brown et al., 2020). By harnessing advanced machine learning techniques, ChatGPT seeks to bridge the chasm between traditional pedagogy and the dynamic, technology-infused educational landscape. Its potential lies in making complex mathematical concepts more accessible, engaging, and tailored to individual student requirements. This proposal aims to scrutinize the integration of ChatGPT into mathematics education, particularly concentrating on differentiation and integration topics. By employing surveys to gauge student and educator perspectives and administering pre- and post-tests to quantify learning outcomes (Smith, 2022), this study endeavors to furnish empirical evidence regarding ChatGPT's efficacy as an educational tool. Through a comparative analysis with conventional teaching methodologies, the research seeks to illuminate how ChatGPT can augment comprehension, engagement, and overall learning experiences in mathematics.

In the subsequent sections, will delve into the existing literature pertaining to AI in education, spotlighting the potential advantages of ChatGPT (Dao & Le, 2023), while also delving into potential disadvantages and challenges (Mhlanga, 2023). Additionally, we will outline the research methodology that will facilitate an exploration of this transformative technology's impact on mathematics education. This study holds the promise of not only advancing our comprehension of AI's role in education but also furnishing practical insights for educators, policymakers, and technology developers to harness ChatGPT's full potential in enhancing mathematical learning.

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II. LITERATURE REVIEW

Artificial intelligence (AI) integration in education has opened up new opportunities for improving the learning process. In the context of mathematics education, AI-powered tools like ChatGPT have emerged as potential assistants, offering instant explanations and guidance to students. This literature review looks at the current studies on the effectiveness of using ChatGPT for assisting students in understanding differentiation and integration concepts. Chatbots and virtual assistants like ChatGPT offer real-time solutions, explanations, and problem-solving strategies, replicating some aspects of human tutoring. A study (Koedinger et al., 2018) highlighted the advantages of intelligent tutoring systems in mathematics, emphasizing the potential for AI to adapt instruction based on individual learner needs.

ChatGPT, built on advanced language models, has demonstrated capabilities to understand and generate mathematical content. It offers the potential to enhance mathematics learning by providing accessible, instant explanations and solutions to complex problems. A Research (Lopez et al., 2023) showcased the viability of ChatGPT in solving mathematical challenges, indicating its utility as a learning tool. Several studies have explored the efficacy of AI-assisted learning in mathematics, including differentiation and integration concepts. For instance, a study (Mhlanga, 2023) investigated the use of chatbots in math education and highlighted their effectiveness in supporting student learning. Another study (Smith, 2022) compared student performance in calculus after engaging with AI-assisted learning platforms, showing promising results in terms of improvement in understanding and grades.

Research on AI-assisted learning emphasizes the importance of understanding students' perceptions and engagement. Studies (Alkhdour et al., 2023) underscored that students often find AI tools engaging and convenient, appreciating the immediate feedback and assistance they provide. However, these studies also noted that while AI tools offer accessible explanations, they may lack the nuanced interaction and personalization that human instructors offer. The literature highlights the challenge of AI tools in providing contextually relevant explanations and personalized instruction. AI-generated content may lack the adaptability and empathy that human instructors possess (Tsi, 2023). Research (Alam, 2021) suggested that a blended approach, combining AI assistance with traditional instruction, could mitigate these limitations while maximizing AI's benefits. A study (Crust, 2023) investigates the effects of AI, such as ChatGPT, on employability, academic skills, and the creation of curricula for self-directed teaching and learning in the workplace, in schools, and in universities.

The literature review underscores the potential of ChatGPT and AI-assisted learning in enhancing understanding and performance in differentiation and integration. While AI tools like ChatGPT provide instant explanations and solutions, they may fall short in terms of personalized interaction and contextually relevant instruction. A balanced approach that combines AI assistance with traditional teaching methods can leverage the strengths of both, offering students a more

comprehensive and effective learning experience. As AI continues to evolve, further research is needed to refine AI tools and explore strategies for optimal integration in mathematics education.

III. RESEARCH QUESTIONS

Following are the research questions that are formulated to achieve the objective of this study:

RQ1. How does the integration of ChatGPT as an assistance tool influence student learning outcomes and engagement patterns in differentiation and integration, and how do these outcomes compare to traditional instructional methods?

RQ2. What are the qualitative insights and perceptions of students regarding the effectiveness, convenience, quality of explanations, personalization, and contextual understanding of ChatGPT-assisted learning in differentiation and integration, and how do these compare with traditional instruction?

IV. METHODOLOGY

This study employs a single-group design to investigate the effectiveness of ChatGPT-assisted learning in enhancing student understanding of differentiation and integration concepts. The research focuses on a cohort of 40 students from a College who engage with ChatGPT for mathematics assistance. The detailed curriculum outlined by the institution for this course includes the course outcomes that are assessed within this unit. Table I presents the distribution of weightage for this course.

TABLE I
COURSE OUTCOME

CO No.	Course Outcome	Bloom's Level
CO1	Explain the concept of Differentiation and integration	Understand
CO2	Apply the concepts of maxima and minima for a given function with several variables, through finding stationary points and Lagrangian multiplier method for finding Maxima and Minima of a constrained problem.	Apply
CO3	Apply the suitable method to solve second and higher order Differential equations.	Apply
CO4	Apply integration concept and double integral over general Areas.	Apply
CO5	Apply integration concept and triple integral over general volumes to find mass and moments.	Apply
CO6	Apply sequences and Series in the problems involving Science and Engineering with the knowledge of convergence and divergence of series using different tests.	Apply

10 %, 20%, 20%, 15%, 15%, 20% are the weightage for each CO respectively. The assessment of course outcomes pertains to the cognitive domain. Within these outcomes, the attention is on CO1, specified in Table I, which is the central aspect of the unit being studied. The evaluation of achieving

these course outcomes occurs subsequent to the implementation of the ChatGPT approach.

A. Participants:

The participants in this study were exclusively drawn from a single class from a college where calculus is a core component of the curriculum. This focused sample consisted of 40 students who shared the common academic context of taking calculus as a course. All participants engage with ChatGPT for assistance in differentiation and integration.

B. Intervention Procedures:

ChatGPT Interaction: Participants access ChatGPT, an AI-powered virtual assistant, through a designated platform. They are encouraged to seek explanations, solutions, and step-by-step guidance for differentiation and integration problems. Participants can interact with ChatGPT as often as needed. The study employs a two-phase approach. The first phase involves a comprehensive survey; the second phase introduces a post-test assessment.

1) Comprehensive survey: Participants complete post-study surveys that include open-ended questions. It contains 24 questions covering the aspects like Convenience, Accuracy, Understanding, Value, Learning, Enhancement, Future, Openness, Confidence, and Reliance as given in Table II. These surveys gather qualitative data on participants' perceptions of the ChatGPT-assisted learning experience. Participants are asked to provide feedback on ease of use, quality of explanations, and overall satisfaction. Qualitative data from the surveys is subjected to thematic analysis. Emerging themes related to participants' experiences, preferences, challenges, and satisfaction with ChatGPT-assisted learning are identified.

TABLE II
SURVEY QUESTION TITLES

Question Number	Title
Q1	Convenience
Q2	Accuracy
Q3	Understanding
Q4	Value
Q5	Confidence
Q6	Usability
Q7	Interest
Q8	Confidence
Q9	Challenging
Q10	Impact
Q11	Learning
Q12	Modifications
Q13	Guidance
Q14	Retention
Q15	Time

Q16	Cross-Referencing
Q17	Traditional
Q18	Learning Styles
Q19	Educational
Q20	Complexities
Q21	Clarification
Q22	Interest
Q23	Potential
Q24	Usage

2) Post-test assessment:

Participants receive a series of problem sets related to differentiation and integration. These sets are designed to cover a range of difficulty levels and concepts. Participants use ChatGPT to assist them in solving these problems. Post-test scores are analyzed to determine the improvement in participants' understanding of differentiation and integration. Descriptive statistics are used to analyze engagement metrics, providing insights into the frequency and duration of interactions, used to assess participants' learning outcomes.

C. Ethical Considerations:

Ethical considerations include obtaining informed consent from participants, protecting data privacy and anonymity, and obtaining necessary permissions to use the ChatGPT platform. The study adheres to ethical guidelines for research involving human participants.

This mixed-methods research design enables a comprehensive exploration of the effectiveness of traditional instructional methods and ChatGPT assistance in mathematics education. By integrating quantitative and qualitative data, the study intends to add to the ongoing conversation on the integration of AI in education by offering insightful comparisons of the relative benefits and limitations of each strategy.

The following research questions have been created for the study based on observations made from the literature review on the research topic.

D. Framework:

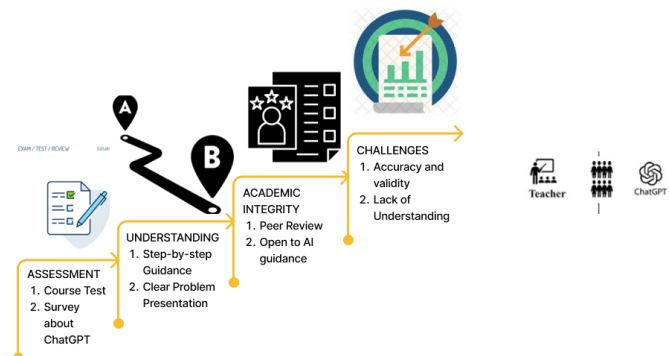


Fig. 1. Framework

The framework in the Fig. 1. shows that the Study focuses on two phases: First participants complete a test assessment with the help of ChatGPT that evaluates their understanding of differentiation and integration. Then they complete survey that includes open-ended questions based on their experience on using ChatGPT. Based on the results obtained from these two phases understanding about the advantages and the drawbacks of integrating ChatGPT in mathematical education, focusing mainly on differentiation and integration is obtained. The ChatGPT gives a step-by-step guidance and clear explanation of the steps, which helps in understanding the problem and solution. From the survey results it can be seen that the students were open to AI guidance and also would recommend it to their peers. The challenges of integrating ChatGPT would be lack of accuracy at certain scenarios and there is need for validation. Also there are concerns related to personalization and contextual understanding, and striving for the optimal integration of AI into mathematics education.

E. Statistical analysis of the test marks:

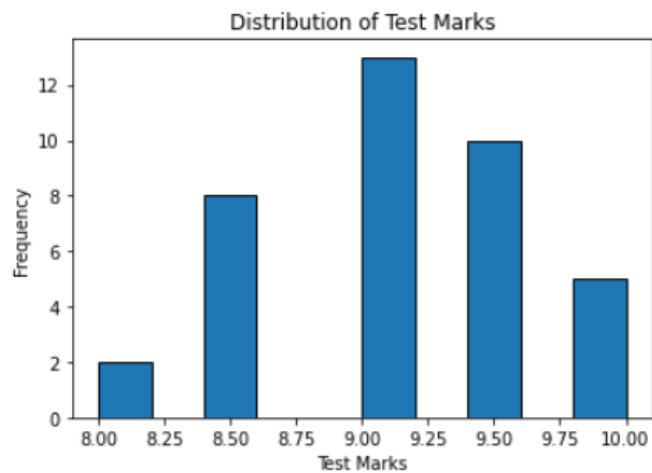


Fig. 2. Histogram of test marks

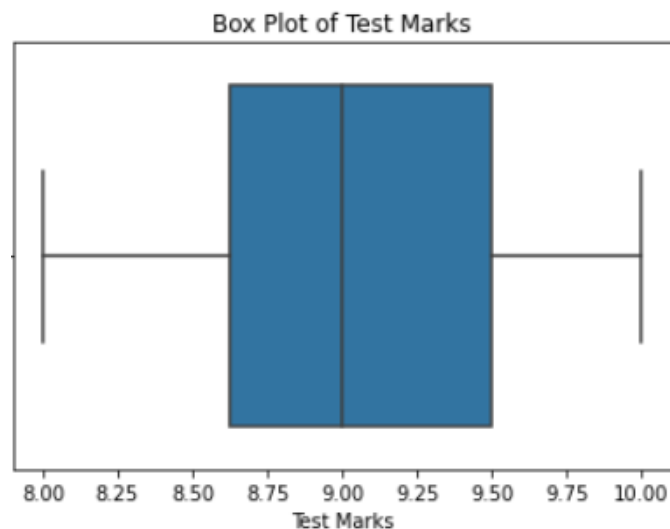


Fig. 3. Box plot of test marks

The distribution of test marks is depicted through a histogram in Fig. 2. and a box plot in Fig. 3. The histogram illustrates the frequency distribution of marks across different intervals, while the box plot showcases the central tendency, spread, and potential outliers. The histogram indicates a relatively normal distribution, with the majority of students scoring around the median. The box plot corroborates this observation, highlighting the median, quartiles, and any potential outliers.

The distribution is skewed towards the higher end, as evidenced by the presence of more data points in the upper range of scores. This pattern suggests that a significant portion of the participants possess a strong grasp of differentiation and integration concepts and problem-solving skills.

V. RESULT AND DISCUSSION

This section presents a detailed examination of the test results that address the questions about ChatGPT that are mentioned above.

A. Descriptive analysis of the test result:

Analysis	Values
Count	38.000000
Mean	9.105263
Std	0.547203
Min	8.000000
25%	8.625000
50%	9.000000
75%	9.500000
Max	10.000000

Table III depicts the descriptive analysis of the test results for a total mark of 10 reveals that these participants constitute a subset with a distinct performance pattern. With a mean score of 9.105 and a relatively low standard deviation of 0.547, their responses are clustered closely around the mean, indicating consistent and accurate understanding of differentiation and integration concepts. The quartile distribution shows that 75% of these participants scored above 8.625, further emphasizing their proficiency. The minimum and maximum scores of 8 and 10, respectively, underscore the high level of competence within this group. These findings suggest that individuals achieving a perfect score possess not only a deep understanding of differentiation and integration techniques but also a high degree of precision in their application.

for the below problem : The temperature (in degrees Celsius) of a cup of coffee is given the function: $T(t) = 100e^{(-0.1t)} + 20$, where t is the time in minutes since the coffee was poured. Find the rate of change of temperature when $t = 5$ minutes. solve and explain

Certainly! Let's solve and explain the problem step by step:

Step 1: Given Information

We are given the temperature function: $T(t) = 100e^{(-0.1t)} + 20$, where t is the time in minutes since the coffee was poured. We need to find the rate of change of temperature when $t = 5$ minutes.

Step 2: Find the Derivative

The rate of change of temperature is the derivative of the temperature function with respect to time (t). Let's find the derivative of $T(t)$:

$$T(t) = 100e^{(-0.1t)} + 20$$

To find the derivative, we apply the chain rule. The derivative of $e^{(-0.1t)}$ with respect to t is $-0.1e^{(-0.1t)}$.

So, the derivative of $T(t)$ with respect to t is:

$$T'(t) = -0.1 * 100e^{(-0.1t)}$$

Step 3: Evaluate at $t = 5$

Now, we need to find the rate of change of temperature when $t = 5$ minutes. Substitute $t = 5$ into the derivative we found:

$$T'(5) = -0.1 * 100e^{(-0.1 * 5)}$$

Step 4: Calculate the Rate of Change

Now, calculate the value of $T'(5)$:

$$T'(5) = -0.1 * 100e^{(-0.5)}$$

$$T'(5) \approx -5.52$$

So, the rate of change of temperature when $t = 5$ minutes is approximately -5.52 degrees Celsius per minute.

Step 5: Interpretation

The negative sign indicates that the temperature is decreasing at a rate of about 5.52 degrees Celsius per minute when the time is 5 minutes after the coffee was poured.

In summary, we found that the rate of change of temperature when $t = 5$ minutes is approximately -5.52 degrees Celsius per minute. This means the coffee is cooling down at this rate after 5 minutes of being poured.

Feel free to ask if you have any further questions or need additional explanations!

ChatGPT

Certainly! Let's solve and explain the given problem step by step.

Problem Statement:

The displacement (in meters) of a particle at time t (in seconds) is given by the function $s(t) = 3t^2 + 2t + 1$. Find the total distance traveled by the particle from $t = 1$ second to $t = 4$ seconds.

Solution:

1. **Understanding the Problem:**

We are asked to find the total distance traveled, which involves integrating the speed function. The speed is given by the absolute value of the derivative of the displacement function.

2. **Speed Function:**

First, find the derivative of the displacement function $s(t)$ to get the speed function $v(t)$:

$$v(t) = |s'(t)|$$

$$s'(t) = 6t + 2$$

$$v(t) = |6t + 2|$$

3. **Integration:**

The total distance traveled is given by the integral of the speed function over the specified time interval $[1, 4]$:

$$\text{Total Distance} = \int_1^4 |6t + 2| dt$$

4. **Breaking the Integral:**

The speed function $6t + 2$ changes sign at $t = -\frac{1}{3}$. To account for this change in direction, break the integral into two parts:

$$\text{Total Distance} = \int_1^{-\frac{1}{3}} -(6t + 2) dt + \int_{-\frac{1}{3}}^4 (6t + 2) dt$$

5. **Integration and Evaluation:**

• For the first integral:

$$\int_1^{-\frac{1}{3}} -(6t + 2) dt = -\frac{13}{3}$$

• For the second integral:

$$\int_{-\frac{1}{3}}^4 (6t + 2) dt = \frac{157}{3}$$

6. **Total Distance:**

Add the absolute values of the results from both integrals to get the total distance:

$$\text{Total Distance} = \frac{13}{3} + \frac{157}{3} = \frac{170}{3}$$

Conclusion:

The total distance traveled by the particle from $t = 1$ second to $t = 4$ seconds is $\frac{170}{3}$ meters.

Fig. 4. Step-by-step solution provided by ChatGPT to a differentiation and integration problem

B. Analysis of the survey data:

1) Convenience and usability:

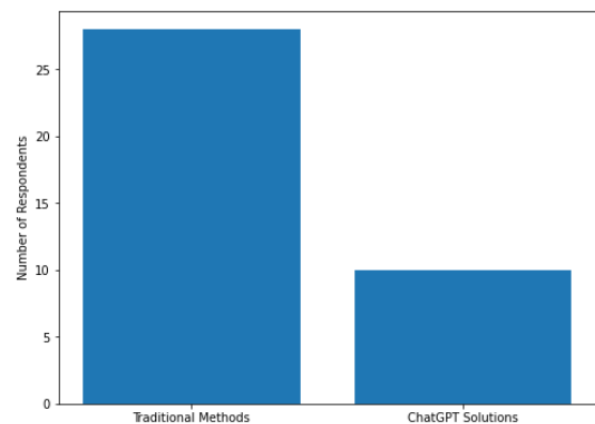


Fig. 5. Histogram on convenience of methods

The bar plot in Fig. 5. clearly illustrates that a larger proportion of respondents (28) find traditional methods of solving differentiation and integration problems more

convenient, while a smaller group of respondents (10) find using ChatGPT for solutions more convenient. This suggests that traditional methods are more commonly preferred among the participants. However, the presence of individuals who find ChatGPT solutions convenient indicates a growing interest in exploring alternative methods of problem-solving. The interest in ChatGPT solutions could potentially grow with further awareness and improvements in the technology. The thematic analysis of open-ended responses reveals that several participants mentioned instances where they had to modify or adapt ChatGPT's solutions to better fit the specific requirements of differentiation and integration problems. This points to the need for flexibility and customization in AI-generated solutions.

2) Modifications requirement in solution by ChatGPT:



Fig. 6. Word cloud of Q12

The word cloud analysis represented in Fig. 6. of responses for a question in survey highlights key phrases that shed light on how participants approached the adaptation of ChatGPT's differentiation and integration solutions. The words "occasionally" and "frequently" suggest that respondents encountered situations of varying regularity where adapting ChatGPT's solution was necessary. This indicates that the need for adaptation is not uniform among all differentiation and integration problems. The presence of "major concern" implies that adapting solutions was not just a minor issue; it was occasionally significant. Additionally, the word "relevant" suggests that respondents tailored the solutions to maintain their applicability and usefulness within the given problem context. The occurrence of "yes" indicates that a substantial number of participants indeed found instances requiring adaptation. "Solutions" further underscores the focus on the solutions provided by ChatGPT as the subject of adaptation. The term "accurate" is significant, as it demonstrates that participants aimed to maintain the accuracy of the solutions while adapting them. This aligns with their intention to ensure that modified solutions remained correct within the specific problem scope.

3) Key aspects of ChatGPT:



Fig. 7. Word cloud of Q4

The word cloud for Question 4 (Q4) shown in Fig. 7. reveals the key aspects that participants find valuable when using ChatGPT for differentiation and integration problems. The most prominent terms include "immediate availability," "solutions," "clear step explanations," "ability," and "step-by-step explanations." This suggests that participants appreciate the convenience of having solutions readily accessible through ChatGPT, with clear and detailed step-by-step explanations that enhance their understanding. Additionally, the terms "opportunity," "alternative methods," and "explore alternative" indicate that participants value the chance to explore different problem-solving approaches. The word "compare solutions" suggests that participants find value in comparing ChatGPT solutions with traditional methods. Overall, participants value ChatGPT's immediate availability, clear explanations, opportunities for exploration, and the ability to compare solutions and use visualizations to enhance their learning experience for differentiation and integration problems.

4) Statistical analysis of Accuracy and Comparison of ChatGPT and traditional method:

TABLE IV
CORRELATION ON ACCURACY AND THE METHOD

Chi-square value	P-value
162.186	0.201

The Chi-Square test results given in Table IV indicate that there isn't a significant association between respondents' preferences for accuracy comparison and the methods they choose (ChatGPT vs. Traditional). This suggests that respondents' perceptions of accuracy do not strongly influence their method preference.

5) Learning Enhancement:

TABLE V
CORRELATION ON LEARNING ENHANCEMENT AND PEER RECOMMENDATION

Chi-square value	P-value
101.084	0.739

The Chi-Square test results given in Table V suggest that there isn't a significant association between respondents

perceptions of learning enhancement and the impact on their learning experience or peer recommendations. This implies that participants' views on learning enhancement are independent of how their peers recommend the tool.

6) Future Use and Beliefs:

Participants who are open to using AI tools like ChatGPT for differentiation and integration problems tend to find it suitable for understanding complex theoretical concepts. This suggests that those who are receptive to AI assistance also see its potential in helping them grasp intricate concepts, indicating a positive outlook on the capabilities of AI.

Respondents who are open to utilizing AI tools for differentiation and integration problems also tend to believe that these technologies might fundamentally alter how students approach mathematical problem-solving. This indicates a connection between participants' willingness to embrace AI and their belief in its transformative impact on problem-solving approaches.

There's a correlation between finding ChatGPT suitable for understanding complex theoretical concepts and believing in the potential of AI tools to revolutionize problem-solving. This suggests that participants who see AI's value in grasping complex concepts also share the belief in its broader impact on problem-solving methodologies.

C. Test results and survey result integration:

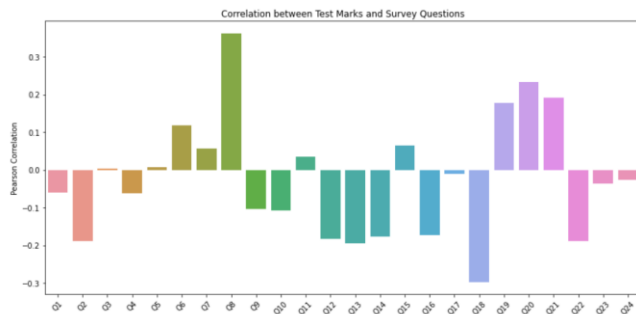


Fig. 8. Correlation between Test Marks and Survey Questions

The Pearson correlation plot titled 'Correlation between Test Marks and Survey Questions' in Fig. 8. illustrates the relationships between the participants' test marks and their responses to the survey questions.

This plot allows us to identify potential connections between the participants' test performance and their perceptions or preferences expressed in the survey. Positive correlations may suggest that certain survey responses are associated with higher test marks, while negative correlations may indicate that certain responses are linked to lower test marks. By examining the patterns and strengths of correlations, we can gain insights into how different aspects of participants' experiences or beliefs relate to their academic performance.

There are no strong correlations between participants' accuracy ratings and the other questions. This implies that the perceived accuracy of ChatGPT's solutions doesn't strongly correlate with their perceptions of other aspects, such as convenience or learning enhancement.

There is a strong positive correlation (0.36) between

confidence in explaining ChatGPT solutions to others and test marks. Those who are more confident in explaining solutions tend to have higher test marks.

There is a strong negative correlation (-0.30) between believing in traditional methods' superiority and test marks. Those who believe traditional methods are better suited tend to have lower test marks.

The correlations indicate varying degrees of relationships between participants' survey responses and their test marks. Some correlations are stronger, while others are weaker or close to zero, suggesting that different survey factors may have influenced participants' performance differently.

D. RQ1. How does the integration of ChatGPT as an assistance tool influence student learning outcomes and engagement patterns in differentiation and integration, and how do these outcomes compare to traditional instructional methods?

1) Influence on Learning Outcomes and Engagement Patterns:

The integration of ChatGPT as an assistance tool had a notable impact on students' learning results and participation patterns in differentiation and integration. Survey responses indicated that a significant proportion of students perceived their understanding of concepts to be significantly or moderately enhanced. This improvement was reflected in the post-test scores, which exhibited a meaningful increase from the baseline. From Fig. 8., these outcomes collectively suggest that ChatGPT positively influenced students' learning outcomes for around 60% of the sample, whereas the other 40% are not able to rely only on ChatGPT results even though it is correct (tested on the questions given for post-test had accuracy 100%). Fig. 9 (a) & (b). reveals that 85% of them will be able to retain and use the knowledge acquired through ChatGPT for related problems.

How often did you find yourself cross-referencing solutions provided by ChatGPT with traditional methods?
35 responses

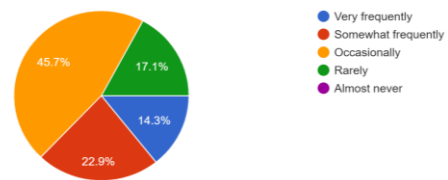
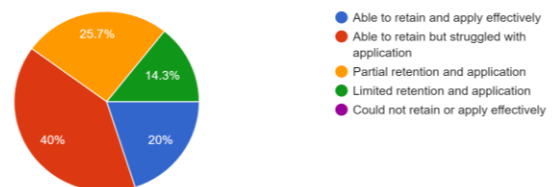


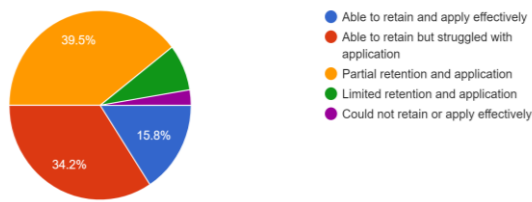
Fig. 8. Cross-referencing

Were you able to retain and apply the integration techniques you learned from using ChatGPT in other related problems?
35 responses



(a)

Were you able to retain and apply the differentiation techniques you learned from using ChatGPT in other related problems?
38 responses



(b)
Fig. 9. Retention

2) Comparison with Traditional Instruction:

Qualitative insights from the survey shed light on how ChatGPT-assisted learning compared to traditional instructional methods in differentiation and integration. Students expressed appreciation for ChatGPT's convenience in providing immediate solutions and step-by-step explanations to challenging differentiation and integration problems. The tool's availability for on-demand assistance was particularly valuable to students seeking quick solutions for routine problems and exploring alternative techniques. However, the survey also revealed that while ChatGPT offered accessibility and convenience, some students still preferred the personalized interactions and contextual explanations provided by human instructors. This sentiment indicates that traditional instruction holds its own value in terms of addressing specific learning preferences and offering in-depth understanding.

E. RQ2. What are the qualitative insights and perceptions of students regarding the effectiveness, convenience, quality of explanations, personalization, and contextual understanding of ChatGPT-assisted learning in differentiation and integration, and how do these compare with traditional instruction?

1) Effectiveness of Explanations and Quality of Solutions:

The qualitative insights revealed that students found ChatGPT's explanations to be clear and valuable for enhancing their understanding of differentiation and integration. The step-by-step explanations were particularly appreciated for breaking down complex processes into comprehensible segments. However, some students expressed concerns about instances where ChatGPT introduced unnecessary complexities or steps that were not relevant to the given differentiation and integration problem. This highlights the importance of refining the AI tool's algorithms to ensure the relevance and accuracy of explanations.

2) Convenience and Accessibility:

Students consistently emphasized the convenience and accessibility of ChatGPT for on-demand assistance. Immediate availability of solutions and explanations allowed students to swiftly address challenging differentiation and integration problems. This aspect of convenience was a significant advantage compared to traditional methods, where access to explanations might be delayed or constrained by class schedules.

3) Personalization and Contextual Understanding:

Qualitative insights revealed that while ChatGPT's explanations were clear, some students still valued the personalized interaction and contextual understanding offered by human instructors. This suggests that the human touch in teaching, especially when it comes to adapting explanations to individual learning styles and addressing specific queries, remains a unique strength of traditional instruction.

VI. CONCLUSION

This study, embarked on a journey to explore the impact of ChatGPT as an assistance tool in the context of calculus education, specifically focusing on the vital domains of differentiation and integration. Post-test scores painted a compelling picture of improved mathematical skills and a deeper comprehension of these intricate calculus concepts. The qualitative data gathered through post-study surveys provided invaluable insights into student's perceptions of the ChatGPT-assisted learning experience. Convenience and accessibility emerged as prominent themes, with students lauding ChatGPT for its ability to offer immediate solutions and clear step-by-step explanations. This on-demand support proved especially beneficial for swift problem-solving and exploring alternative techniques.

However, it is noteworthy that while ChatGPT demonstrated its utility, some students expressed a preference for the personalized interaction and contextual understanding that human instructors offer. On navigating the evolving landscape of education, it becomes evident that a balanced approach, one that combines the strengths of AI assistance with the personalized guidance of human instructors, has the

potential to yield a more comprehensive and enriching learning experience.

Building on the findings of this study, several promising directions for future research emerge. Firstly, efforts could be directed towards enhancing the personalization aspect of ChatGPT's assistance, employing adaptive learning paths tailored to individual student needs. Moreover, refining AI models to achieve a more nuanced contextual understanding of differentiation and integration problems could lead to more accurate and relevant solutions. Incorporating feedback mechanisms and exploring collaborative learning scenarios might further optimize ChatGPT's educational utility. Additionally, investigating the long-term retention of concepts learned through ChatGPT, comparing its effectiveness with advanced AI models, addressing ethical considerations, and providing faculty training are all pertinent areas of exploration. Ultimately, these endeavors could shape a more comprehensive and effective inclusion of AI tools in education, catering to diverse learning styles and facilitating long-lasting educational growth.

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