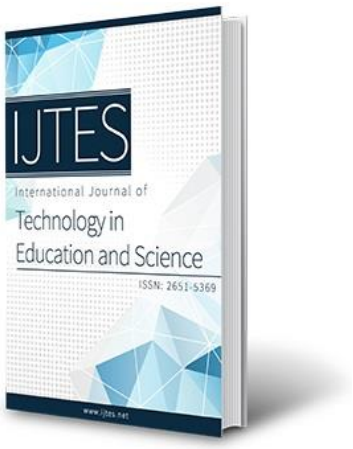

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Abstract

Educators are faced with the sudden infiltration of AI, including artificially intelligent tools that generate content far more sophisticated than any prior technological advancement. In this study, the researchers investigated the use of ChatGPT (currently the most used generative AI tool) as a means of learning Calculus. The study examined student perceptions toward the use of ChatGPT in their learning of mathematical concepts in Calculus and their perceptions of the advantages and disadvantages of its use in the classroom. The participants in this study were 64 undergraduate students enrolled in a Calculus course. Participants completed a 5-point Likert-type questionnaire with two open-ended questions. The collected data were analyzed both quantitatively and qualitatively. Results of the study indicated that most students supported the use of ChatGPT in learning Calculus; they believed that ChatGPT had a positive impact on their learning, and even increased their classroom participation and engagement.

Introduction

'Can machines think?' wondered the father of computer science, Alan Turing, as he explored the possibilities of manufacturing intelligence. Turing supposed that intelligence could be manufactured by training machines to play an imitation game by imitating man's natural responses to specific questions (Turing, 1950). In defiance to prevailing thoughts of his contemporaries, he believed that machines could learn and provide evidence-based solutions. For example, he objected to the beliefs of Ada Lovelace, a highly regarded female mathematician of the nineteenth century, when she suggested that machines can only do what humans tell them to do. He proposed that engineers can train machines by programming them to utilize reflexes as a basis for a form of intelligence that is not quite like human intelligence, as it is artificial. The term artificial intelligence (AI) "is used to classify machines that mimic human intelligence and human cognitive functions like problem-solving and learning" (Team, 2023).

Open AI, a modern technology company, has developed one of the most well-known Large Language Models (LLMs) known as Generative Pre-Trained Transformer GPT. ChatGPT is the software interface for the user-friendly GPT, which is easily accessible to the public. There are many other software interfaces across families of generative engines. Microsoft Corporation competes with OpenAI to develop its own LLM and associated interface. Sydney is Microsoft's LLM. and Bing search engine is its interface. In addition, Google has developed several LLMs, including LaMDA, PaLM, Chinchilla. An increase in the number of LLMs is anticipated.

AI has provided limitless access to information. It has secured its place in today's world and educational arenas must embrace it. While some educational institutions are prepared for that, many are not. Educators have realized that it is imperative to have conversations about generative AI and have started to explore different ways to incorporate such tools within the classroom. Educators of mathematics are no exception. In this paper, the researchers investigated student perceptions of the use of AI technology in the mathematics classroom.

Ever since handheld calculators entered the education sphere, mathematics classrooms have provided a setting for exploring the potential of Artificial Intelligence (AI). Today, educators are faced with the sudden infiltration of generative AI including artificially intelligent tools that generate content far more advanced than calculators can deliver and at rates superseding human ability. New AI capabilities allow users to produce unique representations of music, art, video, text, speech, and code, all within seconds. Such tools can provide accurate and well-described solutions to mathematical problems. However, as queries become more rigorous or convoluted in nature, AI has shown limited capability to grapple with content especially in the field of mathematics. AI can recognize patterns in text and images, not numbers. Students are largely unaware of the limitation.

Literature Review

In their publication, *Principles and Standards for School Mathematics*, the National Council of Teachers of Mathematics [NCTM] (2000) emphasized that technology is an essential component in teaching mathematics and encouraged the use of technology to enhance student learning. Educators and students recognize that AI can aid with writing, analysis, computation, and more (Chan, 2023). The task of learning mathematics may be different and more challenging than learning the other three core subjects: history, language, and science.

Meanwhile, the adaptability of LLMs has been surprising. For instance, in 2022, with 175 billion parameters, GPT-3 stood as the largest-open-source language model (Brown et al., 2020). Brown et al. (2020) found that as the language model got larger, its ability to perform its intended tasks improved without need for additional parameters nor for fine-tuned input. Brown et al. (2020) suggested that these models can self-learn and perform a wide range of tasks beyond what they were designed to perform. Chatbots and ChatGPT currently handle broadly used and structured tasks with accurate outputs, but more nuanced, lesser-known tasks are regularly mishandled (Megahed et al., 2023).

In higher education, there appears to be widespread inconsistency and uncertainty regarding the role of AI in the classroom. The speed at which the technology arrived onto the educational scene has forced educators to create and adopt new policies that address the use of these new tools. There is currently no evidence of consistent established policies across institutions of higher education regarding the implementation of AI in learning spaces.

A professor of animal science at Texas A&M University may have wrongly accused an entire class of submitting AI-generated essays for course credit (Verma, 2023). A professor at Appalachian State University has considered resorting to an exclusive use of oral exams to address students' sudden use of AI (Nolan, 2023). Bans against generative AI have been implemented in schools, only to be lifted amidst uncertainty of how to address this sudden

change. Some institutions simply stress the importance of assignment design (Ravaglia, 2023), while some express alarm over the declining use of trusted resources, such as library databases, claiming that major shifts have occurred since the emergence of generative AI (Gecker, 2023).

George Pallivathukal et al. (2024) investigated students' knowledge, attitudes, and practices in the context of their use of ChatGPT at a Malaysian healthcare university. The participants were four hundred forty-three undergraduate students enrolled at a Malaysian tertiary healthcare institute. The researchers collected data through a 28-item questionnaire that was categorized into three categories: Knowledge, Attitude, and Practice. The questionnaire was shared with the participants through email and social media platforms. The results of the study indicated that participants had concerns about data accuracy, plagiarism, ethical issues, and dependency on ChatGPT for academic tasks. In addition, the results indicated that students with a more positive attitude toward ChatGPT were more inclined to employ it for academic purposes. The researchers concluded that the participants generally held positive attitudes toward the use of ChatGPT in academics.

Jeong et al. (2023) investigated Korean students' perceptions and attitudes toward artificial intelligence (AI). Data were collected using a 24-question online survey that was administered to dental hygiene students from four Korean schools in 2021. The questionnaire included 17 questions on student's attitudes toward AI, their confidence in AI, predictions about AI and its prospects. They found that 44.2% of the participants were interested in the use of AI and appreciated its application and potential for improvement even when they expressed a low level of confidence in it.

Oh et al. (2019) conducted a study to investigate Korean doctors' attitudes toward the medical application of AI. They used an online survey composed of 11 close-ended questions. A total of 669 participants completed the survey. Most of the participants (83.4%) considered AI useful in the medical field, especially in disease diagnosis. Less than half of the participants (43.9%) agreed that AI is diagnostically superior to human doctors. The researchers concluded that Korean doctors and medical students had favorable attitudes toward AI in the medical field. Most surveyed physicians believed that AI would not replace them in the future.

Yüzbaşıoğlu (2020) conducted a study to evaluate the attitudes and perceptions of Turkish dental students towards the use of AI in dentistry. A total of 1103 dental students (650 female, 453 male) at nine dental schools in Turkey completed a 22-question online survey. Most participants (85.70%) agreed that dentistry would be revolutionized by AI and that it is likely to have a positive impact on future dental practice.

Ajlouni et al. (2023) examined university students' attitudes toward using ChatGPT as a learning tool. The researchers collected data from 623 (476 females and 147 males) undergraduate students enrolled at the University of Jordan. The results of the study indicated that the participants in this study perceived ChatGPT as a valuable learning tool and expressed positive attitudes toward its use. On the other hand, some participants (20.7%) reported difficulty using ChatGPT for educational purposes and expressed reservations regarding the precision of the data that it generated. The researchers recommended the use of ChatGPT as part of the curricula and instructional practices at the University of Jordan.

Study (2023) surveyed over 100 educators and 1,000 students in January 2023 to investigate their use and perceptions of ChatGPT in schools. Educators at both the college and grade school levels expressed their concern over students' potential use of ChatGPT to cheat (72% of college professors compared to 58% of grade school educators); 34% of educators believed that it should be banned in schools while 66% expressed support for its use as a resource by students. The participants who used ChatGPT in teaching (21%) indicated that they used it to provide writing prompts (7%), help teach a class (5%), create lesson plans (4%), teach writing styles (4%), and used it as a digital tutor (3%). On the other hand, 72% of college students believed that ChatGPT should be banned from their schools, and 52% indicated that they have used ChatGPT to write an essay for them. In addition, they admitted to using it for to help with homework (89%), at-home tests (48%), writing an essay (53%) and writing a paper outline (22%).

Montenegro-Rueda et al. (2023) conducted a systematic literature review study, in which they reviewed 12 articles that focused on the use of ChatGPT in education. Because the use of ChatGPT in the educational setting is a relatively new practice, all studies were conducted in 2023. The systemic literature review aimed at providing answers to the following three questions:

What is the general state of scientific research on the use of ChatGPT in education?
What are the benefits and challenges of implementing ChatGPT in the classroom?
What are the future trends and emerging research areas in the use of ChatGPT in education?

According to the literature review, scientific research on the use of ChatGPT in education is limited due to its recent implementation in educational settings. The results of the studies indicated that the use of ChatGPT in education has a positive impact on the teaching–learning process. The studies called for teacher training on best and accurate uses of ChatGPT.

Wardat et al. (2023) examined students' and educators' perceptions of the use of AI in teaching mathematics. They conducted a two-stage case study that consisted of content analysis of interviews and investigation of user experience. The results of the study showed that ChatGPT can be a useful educational tool when used with caution.

The inquiry that emerges regarding the use of AI in the mathematics classroom is whether ChatGPT can be effectively used in the mathematics classroom when the tool is designed to manage text rather than numbers. Students might expect that ChatGPT can deliver precise, accurate solutions for a run-of-the-mill quadratic equation, yet be incapable of solving a sixth-root polynomial. The tool may be useful for students who want to compare results of a ChatGPT response with their human-generated analysis, but the student who wants to find solutions without further input can be quite easily misled.

Given the existing gap in literature regarding the use of AI in mathematics education, this study aims to investigate students' perceptions of the use of ChatGPT in their Calculus learning experience along with its advantages and disadvantages.

Research Questions

The purpose of this study was to investigate student perceptions toward the use of ChatGPT in their learning of mathematical concepts and their perceptions of its advantages and disadvantages of its use in the Calculus classroom. This research study aimed at answering the following two questions:

> What are student perceptions of the effects of the use of ChatGPT on their learning of mathematical concepts in Calculus?
> What are student perceptions of the advantages and disadvantages of using ChatGPT in learning mathematical concepts in Calculus?

Method

The participants in this study were 64 undergraduate students at Arizona State University. The students were all enrolled in a Calculus course and used ChatGPT as part of their learning. The course was taught by one of the researchers. Students were enrolled in the course by regular registration procedures and were asked to volunteer to participate in the study as anonymous participants.

Data were collected using a 5-point Likert-type questionnaire with two open-ended questions. The scale ranged between Strongly Agree to Strongly Disagree. The researchers administered the questionnaire in November 2023 during the fall semester. The questionnaire items were developed by the researchers based on the aims of the study and the review of the literature.

Results

The collected data were analyzed both quantitatively and qualitatively. An in-depth analysis of students' responses to the open-ended questions was conducted. For the qualitative part, data were color-coded and organized into different categories based on students' responses.

The responses collected from the 5-point Likert-type survey items were grouped into three categories: students' attitudes toward the use of ChatGPT, students' perceptions of the effect of using ChatGPT on their learning, and students' perceptions of their classroom participation and interaction while using ChatGPT. In addition, students' responses to the questions investigating the advantages and disadvantages of using ChatGPT were tabulated. In the following discussion, the designation of "Agree" includes all "agree" and "strongly agree" responses while the "Disagree" designation includes all "disagree" or "strongly disagree" survey responses.

Regarding the first category investigating students' attitudes toward the use of ChatGPT, 65.63% of the participants agreed that they felt comfortable using ChatGPT while 10.94 % disagreed with the statement. In addition, 53.13% indicated that they would like to use ChatGPT in other classes, while 14.06% disagreed. Most students expressed a favorable level of support for the use of ChatGPT in the classroom (see Table 1).

Table 1. Student ' Attitudes toward the Use of ChatGPT

Item	Agree	Neutral	Disagree
I felt comfortable using ChatGPT in the class.	42	15	7
I enjoyed using ChatGPT in the class.	34	21	9
I would like to use ChatGPT in other classes.	45	10	9
Overall, I enjoyed using ChatGPT in the class.	35	25	4

Regarding the second category investigating students' perceptions of the impact of using ChatGPT on their learning during classroom activities, 53.13% indicated that the use of ChatGPT helped them develop confidence in the course concepts, while 17.19% disagreed. Similarly, 48.44% agreed that the use of ChatGPT made it easier for them to understand the mathematical concepts while 14.06% disagreed. Students' responses indicated that students believed that the use of ChatGPT had a positive impact on their learning (see Table 2).

Table 2. Students' Perceptions of the Effect of Using ChatGPT

Item	Agree	Neutral	Disagree
The use of ChatGPT helped me develop confidence in the course concepts.	34	19	11
The use of ChatGPT made it easier for me to understand the course mathematical concepts.	31	24	9
The use of ChatGPT helped me learn the class content.	32	15	17

Regarding the third category investigating students' perceptions of their classroom participation and interaction while using ChatGPT, 53.13% agreed that the use of ChatGPT helped them participate in the class, while 18.75% disagreed with that statement. Regarding classroom interaction with the instructor while using ChatGPT, 40.63% of students agreed that the use of ChatGPT increased their interaction with their instructor, while 28.13 % disagreed. This indicates that almost half of students felt that the use of ChatGPT had a positive influence on their interaction with their professor. In addition, 43.75% indicated that the use of ChatGPT increased their interaction with their classmates, while 23.44% disagreed. On the other hand, 39.06% of the students indicated that the use of ChatGPT motivated them to seek help from tutors, instructors, and classmates while 35.94% disagreed. Students' responses indicated that students believed that the use of ChatGPT had a mostly positive impact on their classroom engagement and increased their interaction (see Table 3).

Table 3. Students' Perceptions of Participation & Interaction

Item	Agree	Neutral	Disagree
The use of ChatGPT helped me participate in the class in ways that enhanced my learning.	34	18	12
The use of ChatGPT motivated me to actively participate in class activities.	25	20	19

Item	Agree	Neutral	Disagree
The use of ChatGPT made it easier for me to be more engaged in the class discussions.	23	25	16
The use of ChatGPT increased my interaction with my instructor.	26	20	18
The use of ChatGPT increased my interaction with my classmates.	28	21	15
The use of ChatGPT motivated me to seek help from tutors, classmates, and the instructor.	25	16	23

Regarding the second research question investigating the advantages and disadvantages of using ChatGPT in the classroom as perceived by the students, the responses to the two open-ended questions were color coded and divided into different categories. The main advantages, as indicated by students, included using ChatGPT as a resource that can support the instructor's instruction and demonstrate concepts in a different way. They also indicated its benefits in enhancing classroom discussions and providing detailed step-by-step solutions that enhance students' learning. The following table (see Table 4) provides a sample of students' responses.

Table 4. Students' Perceptions of the Benefits of Using ChatGPT

A second Perspective: • ChatGPT has the ability to explain & demonstrate concepts in a way that a professor might not. • It gives a different way of explaining a concept, because it can bring up a different way of solving a problem. • It can find a new/different way to solve a problem. • It can offer an alternative outlook on a problem or concept that encourages new ways of thinking.
Detailed Explanation: • Provides another source to help students better understand what's happening in the class by going step by step how to do the work. • Provided a step by step approach to solving problems that was easy to digest and understand. • It can give detailed and specific steps and answers to problems. • It will show you how to do the math and what steps to take. This will also help because the teacher can't always help you if she is helping a lot of people. • It provide a very detailed explanations very quickly. It can help solve problems that one be stuck on and it can also describe certain mathematical concepts.

Interactivity: • Since ChatGPT is not 100% accurate, it encourages the instructor and students to analyze and go through the process of a problem and catch any errors that ChatGPT might made. • ChatGPT benefits the class by aiding in the class discussions. I liked how it explained things in a different way which helped clear up any possible misunderstandings in the unit. • ChatGPT can summarize concepts so that they are easier to understand. • It gives another form of interactive learning inside the classroom.
Personal: • It can be presented as a way of a personalized learning experience. • It's more personalized than looking at websites. • It helps to be an assistant when you don't know a concept when you might not have help around. • It helps me learn how to solve a problem I'm struggling on and allows me to see the steps, so I can use those steps to solve similar problems. It also allows me to double check my answer and see where I went wrong.
Other: • It is great if used as a time saver. • I also liked how using ChatGPT in the class helps me become more knowledgeable about new technology. • I can use ChatGPT to learn course before I start class.

The main disadvantages that were mentioned by students regarding the use of ChatGPT can be divided into four categories: confusion & accuracy, not learning, math issues, and interaction. The following table (see Table 5) provides a sample of students' responses.

Table 5. Students' Perceptions of the Disadvantages of Using ChatGPT

Confusion & Accuracy: • ChatGPT can be a bit confusing in its descriptions & may be wrong. • Sometimes ChatGPT can confuse me more, because it brings up a method that I have never seen. • It isn't very accurate. It frequently gave me incorrect answers. • It's usually wrong or takes way too much to get right. • The answer can be wrong. This wasn't a problem in class because we could go over why it was wrong but at home it might cause confusion. • Incorrect solutions, sometime the program can't do every type of problem.
Not learning: • Students may rely on it to much just to get the answer and not actually learn

anything from it. • Relying on ChatGPT for answers. • May allow students to get right answer on quiz/homework but not understand concepts. • Not use much brain, just ask ChatGPT and then will get the answer from there. • The danger of students outsourcing the homework to this software and miss the learning opportunity. • ChatGPT does not enhance understanding. • You won't learn properly and you will only learn very short shortcuts that don't allow you to see the beauty of mathematics. • Students using ChatGPT for answers without learning the material. • Using to simply solve the answer, so homework can get done faster. • The only thing that it could be hindering is the critical thinking aspect of working through difficult problems.
Math Issues: • ChatGPT is not made to handle math and asking the right questions can be difficult. • ChatGPT is unreliable when used for Calculus. • ChatGPT is not a math program. It is difficult to operate for math purposes. • It can be very tricky to get it to solve an actual math problem correctly. • It is hard to type math equations into ChatGPT.
Interaction: • It might be a reliant to some people too much which might stop them from interaction with others for help. • Decreases interaction between students. • It can sometimes discourage students from practicing in the homework & studying when they can get the answers from AI.

Conclusion

The significance of this study lies in its exploration of undergraduate students' perceptions regarding the integration of ChatGPT within the mathematics classroom, an area that has seen limited research. The results indicated that most students in this study expressed a positive attitude towards the use of ChatGPT in the mathematics classroom. Also, it indicated that students believed that the use of ChatGPT had a positive impact on their learning, their classroom participation and interaction with peers, tutors, and instructors. Students perceived ChatGPT as a resource that could supplement instruction and explain concepts in different ways, enrich classroom discussions and provide detailed step-by-step solutions that can enhance student learning. On the other

hand, students also mentioned that there were disadvantages to using the AI tool such as confusion and lack of learning. The researchers call for further studies that investigate the potential role of AI in enhancing student success in the learning of calculus and mathematics.

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