

RESEARCH ARTICLE

ChatGPT and other AIs: Personal relief and limitations among mathematics-oriented learners

Jocelyn P. Remoto

Zamboanga Peninsula Polytechnic State University, Zamboanga del Sur 7000, Philippines; jocelynremoto@gmail.com

ABSTRACT

Mathematics utilizes symbolic language, logics, relationships, and numerical connections that made it challenging for students to learn and develop their computational skills. Recently, artificial intelligence emerged as a supplement tool for education and learning because of its ability to detect relationships and logics. Academic institutions are looking on how to implement AI-assisted learning specifically for mathematics to aid in increasing the quantitative competence of students. This study analyzed the relief and limitations of AI chat models in learning among mathematics-oriented students in higher education. Fifteen students participated in this study from mathematics-oriented courses e.g., engineering, statistics, and education. Interviews were conducted on how students used AI chat models to assist in learning mathematical concepts and methods. Narratives indicated that AI chat models like ChatGPT and Bard were capable of accurately responding to chat prompts in problem solving, proving, and explanations. It was prominent that these AI models understood the mathematical language and use of symbols for integration, derivatives, limit, fractions, exponentials, and intervals. At some instances, AI models could give inaccurate results or incorrect methods for solving; they also sometimes give correct answers on second run of chat prompts after these mistakes. These results had promising implications in education as these accessible AI models could reinforce the firsthand learning of mathematical foundations. This preliminary study offered important usability of AI models in mathematics in assisting students and monitoring their learning progress.

Keywords: AI chat models; artificial intelligence; assisted learning; Bard; ChatGPT; mathematics

1. Introduction

Mathematics, as an academic discipline, encompasses the utilization of symbolic language to express and convey concepts pertaining to numerical quantities, magnitudes, spatial arrangements, and structural frameworks^[1]. Mathematics education has been characterized as a demanding subject aimed at enhancing students' proficiency in problem-solving. Students commonly encounter significant challenges when attempting to complete mathematical problems, particularly those that necessitate the completion of multiple steps^[2,3].

Scholars within the academic community have endeavored to develop several kinds of pedagogical approaches and technological tools aimed at enhancing students' mathematical academic performance. Hence, the goal of this study was to assess the advantages and disadvantages of using AI chat models in learning mathematics based on the experiences of mathematics-oriented students.

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Artificial intelligence has the potential to fulfill several functions within the field of education. These roles encompass that of an innovative lecturer, a trainee, an instructional device, an assistant, and an advisor for academic policymaking^[4]. AI, especially the study of machine learning^[5-7], provides a range of methods for accurately identifying patterns in data, and its usefulness in several scientific fields is growing^[8]. AI has proven to be a useful tool in mathematics by demonstrating counterexamples to established conjectures^[9], speeding up computations^[10], producing symbolic solutions^[11], and identifying the presence of organization in mathematical objects^[12]. It is also important to consider that instructors and teachers are making efforts to expand their instructional strategies and improve delivery of course contents^[13].

In Ecuador, AI models were used to characterize the strengths and weaknesses of students and develop a program that aids their educational needs. Utilizing the existing knowledge and aptitude of students, as well as acknowledging their individual strengths and areas for improvement, the recently developed AI-driven learning platform has successfully created intelligent tutors that effectively assist both students and educators throughout the educational journey^[14]. In the study of teachers also use ChatGPT, an AI chat model, to do their lesson plans with interesting approaches and innovative designs^[15].

AI technologies, like by ChatGPT, which is fueled by the advanced GPT-4 model, have exhibited noteworthy promise in revolutionizing the way students acquire knowledge and engage with information. As the utilization of AI-driven tools continues to advance in extent and accessibility, it is imperative to delve into their impact on students and educational institutions, with a specific focus on universities.

Various studies had been conducted on the application of AI models in education. Thorp^[16] highlights the potential drawbacks of employing ChatGPT in educational settings, shedding light on the implications it may have on the scientific and academic fields. While ChatGPT exhibits proficiency in generating articles on diverse subjects, its aptitude for academic writing is still in the developmental stages. The benefits associated with ChatGPT encompass personalized learning, fostering interactive learning experiences, and the capacity for formative assessment, which aids in both teaching and learning processes while offering ongoing feedback^[17]. The ChatGPT model has been identified as having certain concerns pertaining to the generation of misinformation, potential biases in its training data, and privacy-related considerations^[18].

In the model proposed by Artificial Intelligence in Education (AIEd), Paradigm 1 suggested that the role of AI in the learning process is to embody domain understanding and guide the various learning activities, while the learner assumes the role of a recipient of AI services, following predefined learning pathways^[19]. Paradigm one looks learning as a process of reinforcing the acquisition of knowledge by means of programmed instructions through introducing new concepts in a logical and progressive manner, ensuring that the learner receives immediate feedback regarding any incorrect responses^[20,21]. This approach aims to maximize positive reinforcement throughout the learning experience.

Paradigm Two of AIEd can be described as an AI-supported approach where the learner takes on the role of a collaborator^[19]. The learner and the AI system work together as collaborators, with the primary focus being on the learning process of each student. The second paradigm is based on the principles of cognitive and social constructivism. This perspective emphasizes the belief that learning takes place when a learner engages with individuals, technology, and information within socially situated environments^[22,23].

Paradigm Three can be described as an AI-empowered approach that places the learner in a leadership role, with learner agency being the central focus of AI in education^[24]. This paradigm perceives AI as a tool that enhances human intelligence^[19]. In the context of this complex system, it is imperative to approach the design and implementation of AI in education with a comprehensive understanding that AI techniques are

integral components within a broader framework encompassing learners, instructors, and other human entities^[25,26].

As previous theoretical foundations suggested, the establishment of the field of AI in education necessitates the progressive refinement of learner-centric, data-informed, personalized learning approaches in the contemporary era of knowledge acquisition^[19,27–30].

The goal of this study was to assess how students used AI chat models e.g., ChatGPT and Bard by Google, to assist them in solving, computations, development of reports, and explanations specifically in mathematics. This study was beneficial in understanding how these conversational models respond to chat prompts and what particular limitations it had. This study was a preliminary research that collect data on the advantages and limitations of AI chat models in responding to chat prompts which then be used in programming a higher education curriculum for mathematics learning. As a process of analysis, this study run some chat prompts to AI models to test their mathematical capacity in solving both numerical and worded problems.

2. Research objectives

Relief and limitations in using AI models in mathematics were important aspects of learning needed to be studied. It was essential to provide in-depth analysis on the experiences of mathematics-oriented learners to discover new perspectives on how AI models develop learning which aspects it hindered. Below are the research objectives of this study.

- 1) Determine the relief of ChatGPT and AIs to mathematics-oriented learners from their academic tasks.
- 2) Determine the limitations ChatGPT and AIs to mathematics-oriented learners from their academic tasks.

3. Methods

This study explored the relief and limitations of using ChatGPT and other AI models in mathematics-oriented learning. This study analyzed the experiences on mathematics-oriented learners when they use AI models in learning mathematics. These experiences widely covered both positive and negative aspects of AI models. Personal relief represented how AI models helped students while limitations described the challenges in using AI models. This analysis developed new perspectives on how AI models reinforce learning, and the narratives of mathematics-oriented learners presented a framework for potential use of AI models in computing.

3.1. Research design

This study employed an exploratory research design to investigate the relief and limitations of using ChatGPT and other AI models in mathematics-oriented learning. By adopting an exploratory design, the study developed a comprehensive understanding of the experiences of mathematics-oriented learners when using AI models in their mathematics learning process. This design facilitated an in-depth exploration of both the positive and negative aspects of AI models, allowing for the development of new perspectives on their role in reinforcing learning.

Exploratory design is “the initial research, which forms the basis of more conclusive research. It can even help in determining the research design, sampling methodology and data collection method”^[31]. This study mainly employed interpretative approach to describe the relief and limitations of using AI models in mathematics learning. The narratives from interviews do not present conclusive empirical result, but only a projection of experiences^[4,32].

3.2. Participants and sampling technique

The participants in this study were purposively selected mathematics-oriented learners from various educational institutions, including schools and universities. The selection criteria were based on their willingness to participate^[33,34] and their experiences using AI models for mathematics learning. Initial interview was done to determine if the student use AI models specifically in mathematics activities, take home quizzes, and modules. Researchers “use purposive sampling...to learn a lot from a small sample and understand the subject area well enough to know which subjects are vital to the project”^[35]. The demographics of the participants are presented in **Table 1**.

Table 1. Basic information of participants.

Code	Name	Gender	Age	Student demographic	AI used
Participant 1	Raymar	Male	24	4th-year education (mathematics major)	ChatGPT; Bard
Participant 2	Carlo	Male	22	3rd-year engineering	ChatGPT
Participant 3	Reyzel	Female	21	2nd-year education (mathematics major)	ChatGPT; Bard
Participant 4	Aldrin	Male	18	4th-year engineering	ChatGPT
Participant 5	April	Female	19	4th-year statistics	ChatGPT
Participant 6	Arnel	Male	21	1st-year education (mathematics major)	ChatGPT; Bard
Participant 7	Christine	Female	20	2nd-year education (mathematics major)	ChatGPT
Participant 8	Ella	Female	23	3rd-year statistics	ChatGPT
Participant 9	Enzo	Male	22	4th-year engineering	ChatGPT; Bard
Participant 10	Gia	Female	18	2nd-year engineering	ChatGPT
Participant 11	Joshua	Male	19	3rd-year engineering	ChatGPT
Participant 12	KC	Female	20	1st-year education (mathematics major)	ChatGPT; Bard
Participant 13	Farah	Female	23	4th-year statistics	ChatGPT
Participant 14	Lawrence	Male	21	3rd-year engineering	ChatGPT; Bard
Participant 15	Nathaniel	Male	20	2nd-year statistics	ChatGPT

The sample size was determined through data saturation, ensuring that sufficient information was gathered to address the research questions adequately. Efforts were made to include participants from diverse backgrounds to capture a range of experiences and perspectives. In this study, students from engineering, education major in mathematics, and statistics were interviewed.

Purposive sampling was effective sampling technique for this study because it was able to target specific demographics of college students with mathematics units. This study chosen participants with at least 70 mathematics-based units. Purposive sampling ensured that the participants are enrolled in mathematics-oriented courses.

3.3. Research instrument

This study developed a research instrument that captured the responses of the participants based on the study objectives. Interview questions provided relevant experiences of mathematics-oriented learners on using AI models in academic settings. This study used guidelines in conducting interviews developed by Esterberg^[36]. The interview questions in **Table 2** were specifically designed to allow participants to express their ideas, opinions, and concerns about using AI models in computing and mathematics learning.

Table 2. Interview guide questions.

Objectives	Interview questions	n
1) Determine the relief of ChatGPT and AIs to mathematics-oriented learners from their academic tasks.	1) In terms of you, as mathematics-oriented learners, what relief can ChatGPT or AI give you? 2) What relief can ChatGPT or AI give you in your loaded academic requirements?	15
2) Determine the limitations ChatGPT and AIs to mathematics-oriented learners from their academic tasks.	1) In terms of you, as mathematics-oriented learners, what limitations did you experience in using ChatGPT or AI? 2) What limitations did you experience in using ChatGPT or AI in accomplishing your academic tasks?	15

3.4. Data gathering procedure

Qualitative data collection methods were utilized to capture the participants’ experiences with AI models in mathematics-oriented learning. The primary data collection technique involved semi-structured one-on-one interviews with the participants. The interviews provided an opportunity to delve deeply into the participants’ personal relief experiences and the limitations they encountered when using AI models.

Before conducting an interview, this study secured a permit for data collection from the school administration. The researcher request approval from the head of student affairs to conduct the study. After securing these requirements, the researcher wrote a consent with voluntary participation clause, research objectives, data use, confidentiality, and distribution of results to be given to the participants. Upon signing, the researcher scheduled time for interview conducted through phone calls. The interviews were audio-recorded, and field notes were taken to capture non-verbal cues and contextual details.

This study also collected chat prompt responses from ChatGPT and Bard by Google to relate to the responses of the participants. The questions asked to AI models were computational and written format. This process provided support for the responses from the interviews.

3.5. Data analysis

The primary data in this study were the narratives from the participants and the secondary data were the responses to chat prompts from AI models ChatGPT and Bard by Google. Thematic analysis was employed to analyze the narratives obtained from the interviews. Thematic analysis employs “analyzing the patterns and themes within your data set to identify the underlying meaning”^[37]. The analysis process consisted of several stages. Firstly, the audio-recordings of the interviews were transcribed verbatim, ensuring fidelity and accuracy of the narratives. The transcripts were then coded using a combination of inductive and deductive approaches. Initially, an open coding process was undertaken to identify significant units of data related to personal relief and limitations experienced by mathematics-oriented learners. These codes were refined, grouped, and organized into themes and sub-themes. The themes and sub-themes were constantly reviewed and refined throughout the analysis process to ensure their coherence and relevance to the research questions.

4. Results and discussion

4.1. How AI aids learning mathematics

The use of ChatGPT turned into a platform for last-minute submission of class assignments, and AIs really prevent students’ academic standing from failing. Out of the 30 participants, fifteen (15) respondents said that using ChatGPT is more practical and accessible since it teaches students how to build logical phrases. Additionally, the employment of AIs aids students in developing engaging presentations that are pertinent to

the subject matter and avoid time-consuming work. The remaining fifteen (15) participants added that using ChatGPT and AIs is only advised for tasks like writing essays, not for problems requiring mathematical solutions (Calculus & Physics). The data collected showed that using ChatGPT and AIs assists math-oriented students with essay tasks rather than mathematical solutions, since those activities require systematic methods.

“It’s convenient and very accessible. When you chat about the entire question or when you chat the specific question that you want to get an answer with, in a few seconds it will give you the paragraph or the entire essay. So, you can right away get the information that you want.” [Participant 2]

“It really helps students like us. Mathematics is very hard, and we use AI like ChatGPT, to explain some mathematical concepts so we can understand it clearly.” [Participant 11]

“I use AI when doing essays; it’s more on like written, like essays. When you’re in learning mathematics, it’s not really more on essays. But if you type the math expression, it can give you explanations. It is one of the advantages when you use ChatGPT.” [Participant 4]

“AI models help you learn math. I use it in solving some basic questions to even proving mathematical statements. It can give you somehow correct answers.” [Participant 3]

“I sometimes use ChatGPT to solve. It can provide some explanations how it derived the answers. You may also check yourself if its answers were correct or not.” [Participant 5]

“In logic, mathematics also has logics. In logic, I think AI can help because logic in mathematics is fixed.” [Participant 8]

“Instead of wasting time making presentations for reporting, we use these technologies to help in our reports.” [Participant 13]

“I rarely use AI in solving math problems, I use them when making narrative reports even in math because it can explain important concepts in very simple manner.” [Participant 12]

There were differences on how mathematics-oriented learners used AI models in their academic tasks. Some of them use AI in written outputs while others also use them in solving mathematical problems. As one of the students said, “AI models help you learn math” [Participant 3].

Those students who use AI models in written outputs perceived that AI models were most built for written outputs. This was an important perspective because AI models were able to help students when doing presentations in mathematics. In contrast, some mathematics-oriented students were using AI models to solve math problems. This was another relevant component of mathematics learning because apparently, AI models can give both solutions and explanations to their prompts. These reinforcements in learning enabled the students to answer some challenging questions.

ChatGPT was able to correctly answer the chat prompts as presented in **Table 3**. These chat prompts were seeking for solution and explanations on mathematical problems. In comparison, for Prompt 1, Bard had inconsistency in its solution yielding -2 as its final answer. In Prompt 2, it had similar explanation with ChatGPT but explained it clearly and concisely. This indicated somehow promising use of AI models in explaining important mathematical concepts (Prompt 2) and assisting computational problems (Prompt 1). As one student said, “It’s convenient and very accessible” [Participant 2]. Some students used AI models to learn basic mathematical concepts e.g., integration and proving.

AI has been in mathematical studies for a long time. The pedagogical approach employed by the school in its mathematics curriculum predominantly emphasizes theoretical instruction. In the realm of applied mathematics education, it is evident that the current practical curriculum framework is notably limited in scope.

Consequently, this inadequacy hampers the effective execution of mathematical applications^[38-42]. ChatGPT offer instant feedback and assistance, particularly in the context of aiding students who require immediate support in resolving mathematical problems^[43]. This study provided important application of AI chat models in learning mathematics based on the experiences of its users. Reason of the students of using AI models were its accessibility and instant responses to chat prompts.

Table 3. Chat prompt response.

Chat prompt	Response	
	ChatGPT	Bard by Google
Evaluate $\int \sin x \, dx$ from $[0, \pi]$.	Evaluating this definite integral over the interval $[0, \pi]$, we have: $\int [0, \pi] \sin(x) \, dx = [-\cos(x)]$ [from 0 to π] $= -\cos(\pi) - (-\cos(0))$ $= -(-1) - (-1)$ $= 1 - (-1)$ $= 1 + 1$ $= 2$	The integral of $\sin x \, dx$ from $[0, \pi]$ is 2. $\int \sin x \, dx$ from $[0, \pi]$ $= -\cos x$ from $[0, \pi]$ Evaluating the definite integral, we get: $-\cos x$ from $[0, \pi]$ $= [\cos \pi - \cos 0]$ $= [-1 - 1]$ $= -2$ Therefore, the integral of $\sin x \, dx$ from $[0, \pi]$ is 2.
If A is a nonempty set, explain why there could be no function that exists from A to \emptyset .	If A is a nonempty set and \emptyset is the empty set, there can be no function that exists from A to \emptyset . This is because for any element a in A , there is no element in \emptyset that can be assigned to it. Since \emptyset has no elements, there is no way to satisfy the condition of assigning exactly one element of \emptyset to each element of A . Therefore, the empty set \emptyset cannot serve as the codomain (the set of possible output values) for a function from a nonempty set A . In order for a function to exist, there must be at least one element in the codomain that can be assigned to each element in the domain (set A).	If A is a nonempty set, then there must be at least one element in A . However, the empty set, \emptyset , has no elements. Therefore, if there were a function from A to \emptyset , then it would have to map every element of A to the unique element in \emptyset , which is nothing. But this is impossible, because nothing is not a unique element. In other words, a function from A to \emptyset would have to satisfy the following two conditions: 1) For every element a in A , there is a unique element b in \emptyset such that (a, b) is in the function. 2) The element b in \emptyset is unique for each element a in A .

In terms of response accuracy, AI models also showed promising results. The accuracy of ChatGPT’s responses plays a pivotal role in determining its success and the extent to which it can be effectively integrated into school operations^[43,44]. Generative AI models have the potential to offer students engaging and captivating educational experiences that are specific to their unique learning styles and individual needs^[45,46]. For some students, “I use AI when doing essays” [Participant 4] and “we use these technologies to help in our reports” [Participant 13]. Most students use AI chat models to generate essays and explanations because it can provide accurate prompt response for them. Language models have exhibited exceptional proficiency when it comes to a diverse range of tasks involving natural language, even in quantitative reasoning^[47].

In this study, Prompt 2 in **Table 3** was correctly answered by ChatGPT and Bard. It is true that there are no functions from A to \emptyset that exist because there should be a corresponding output in \emptyset for every input in set A . Bard, however, provided a mathematical proof for this as indicated:

Let f be a function from A to \emptyset . Then for every element x in A , there must exist a unique element y in \emptyset such that $f(x) = y$. But since \emptyset is the empty set, there are no elements in \emptyset . So this is a contradiction, and there can be no function from A to \emptyset . [Response from Bard]

AI models can provide an actual mathematical explanation to student questions because it is programmed to respond to user’s input^[48-50]. One student thought that “AI can help because logic in mathematics is fixed” [Participant 8]. In this study Bard used proof by contradiction to explain how Prompt 2 is correct.

In computational aspects, AI models had inaccurate responses to prompts. Although ChatGPT and Bard were modelled for general input-response concept, they had useful applications in computational math^[47]. For instance, ChatGPT and Bard understood the mathematical symbols for “integration” (i.e., $\int dx$) and “close intervals” (i.e., [...]). Minerva, an AI model for computation, also had similar concerns that “the model can arrive at a correct final answer using incorrect reasoning steps”^[47]. This was also prominent in Bard’s response in Prompt 1 as it arrived to correct answer but had miscalculations in its previous steps. Bard was not able to indicate the negative sign in its solution before evaluating the definite integral.

Nevertheless, because of the ability of AI models to respond to some mathematical inputs, students used them to generate answers. Whether the input was explaining mathematical concepts, proving, or computation, AI models had possible proficiency to reinforce learning in mathematics.

4.2. Limitations of using AI in learning mathematics

According to the data gathered, each of the thirty (30) respondents claimed that using ChatGPT reduced their capacity for sentence construction and made them less patient when looking for reliable sources for their research. However, ten respondents claimed that AIs lacks credibility because the sources and information used are questionable and only provide surface-level knowledge. Additionally, the data reveals that learners who are interested in mathematics began to doubt the validity and applicability of this platform due to the informational limits of ChatGPT and AIs. Additionally, these platforms are only advised for essay-related work; they are not advised for tasks of a mathematical nature.

“More on the limitations is when AIs cannot give sources on how they were able to solve the problem. They only give you the methods how they solved the problem. I think, that is the limitations of ChatGPT and other AI.” [Participant 6]

“ChatGPT is modeled for chats. When you ask simple questions, it can give you answers. While in mathematics, you will encounter many mathematical symbols that you cannot type in ChatGPT. This is its limitation because it is not built specifically for math.” [Participant 7]

“I think, even if AI gives you answers in math, in some instances, what it gives is wrong or incomplete. So, I think, when using it, you should also know the foundation of mathematics so you can check if what it gives is correct.” [Participant 9]

“The limitation is the extent of information it gives. It’s like surface level only. It also cannot give specific information especially if you ask it to do mathematical problem solving.” [Participant 1]

“When the problem is solving-worthy questions. I’m not usually using ChatGPT in problem solving. And when it comes to calculus or physics that need to solve with numbers, I’m not usually using ChatGPT.” [Participant 10]

“One of my concerns in using AI is it can provide you with wrong answers. Because you cannot understand how it came up with these answers, you will automatically believe that what it says is correct.” [Participant 15]

“In using AI, I think, we should be careful because what it says could be wrong or inaccurate.” [Participant 14]

Some students expressed their concerns about the limitations of AI models in learning mathematics in doing academic tasks. Students see AI models as an important resource in learning, but it had some important limitations e.g., incompleteness, inability to answer complex questions and often answer them incorrectly, need for guidance and corrections.

Students who use AI models in written works often observed its incomplete response that needed refinement and clarifications. Sometimes, it gave unclear explanations and had insufficient information. One student suggested that “you should also know the foundation of mathematics so you can check if what it gives is correct” [Participant 9]. This explained some mathematics-oriented learners observed some mistakes on how AI models answer prompts related to mathematics. This was the major limitations of using AI models in learning mathematics.

Table 4. Chat prompt response.

Chat prompt	Response	
	ChatGPT	Bard by Google
Evaluate $\int \frac{1}{x^2} dx$ from $[-1, 1]$.	<p>To evaluate the integral $\int (1/x^2) dx$ over the interval $[-1, 1]$, we need to find the antiderivative of the function $(1/x^2)$ and then evaluate it at the limits of integration. The antiderivative of $(1/x^2)$ is given by:</p> $\int (1/x^2) dx = -1/x$ <p>Now, we can evaluate this antiderivative at the limits of integration:</p> $\int_{\text{from } -1 \text{ to } 1} (1/x^2) dx = [-1/x] \text{ from } -1 \text{ to } 1$ <p>Substituting the limits into the antiderivative, we have:</p> $[-1/x] \text{ from } -1 \text{ to } 1 = [-1/1] - [-1/-1] = -1 - 1 = -2$ <p>Therefore, the value of the integral $\int (1/x^2) dx$ over the interval $[-1, 1]$ is -2.</p>	<p>The integral of $1/x^2$ is $-1/x$, so the integral of $1/x^2$ from $[-1, 1]$ is:</p> $\int 1/x^2 dx \text{ from } [-1, 1]$ $= (-1/1) - (-1/-1)$ $= 1 + 1$ $= 2$
A 10-meter-long ladder is leaning against a brick wall forming like a triangle on the first quadrant of cartesian plane. If a worker pulled the ladder horizontally towards the brick wall at a rate of 2 m/s, how fast would the top of the ladder slides upward when its bottom is 6 meters from the wall?	<p>Using the Pythagorean theorem, we have the relationship:</p> $x^2 + y^2 = L^2$ <p>Taking the derivative of both sides of this equation with respect to time t, we get:</p> $2x \frac{dx}{dt} + 2y \frac{dy}{dt} = 0$ <p>Substituting the values into the equation and solving for $\frac{dy}{dt}$, we have:</p> $(2)(6)(2) + 2y \frac{dy}{dt} = 0$ $24 + 2y \frac{dy}{dt} = 0$ $2y \frac{dy}{dt} = -24$ $\frac{dy}{dt} = \frac{-24}{2y}$ <p>Now, we need to find the value of y when the bottom of the ladder is 6 m from the wall. Using the Pythagorean theorem again:</p> $x^2 + y^2 = L^2$ $36 + y^2 = 10^2$ $y^2 = 24$ $y = 8$ <p>Substituting this value of y into the equation for $\frac{dy}{dt}$, we get:</p> $\frac{dy}{dt} = \frac{-24}{2(8)}$ $\frac{dy}{dt} = -3$ <p>Therefore, the top of the ladder is moving at a rate of -3 m/s (negative sign indicates downward direction) when the bottom of the ladder is 6 meters from the wall.</p>	<p>Let's use the Pythagorean theorem to relate the length of the ladder (10 m) to the horizontal distance (x) and the vertical distance (y) of the ladder from the wall.</p> $x^2 + y^2 = 10^2$ <p>We are given that $x = 6$ m, and we want to find the rate at which y is changing (dy/dt). We also know that the rate at which x is changing is $dx/dt = 2$ m/s.</p> <p>Let's differentiate both sides of the equation with respect to time:</p> $2x \frac{dx}{dt} + 2y \frac{dy}{dt} = 0$ <p>Plugging in the known values, we get:</p> $(2)(6)(2) + 2y \frac{dy}{dt} = 0$ $24 + 2y \frac{dy}{dt} = 0$ $2y \frac{dy}{dt} = -24$ $\frac{dy}{dt} = \frac{-24}{2y}$ <p>We know that $y = 10 - x = 10 - 6 = 4$ m when $x = 6$m.</p> $\frac{dy}{dt} = \frac{-24}{2(4)}$ $\frac{dy}{dt} = -3 \text{ m/s}$ <p>Therefore, the top of the ladder is sliding upward at a rate of -3 m/s. The negative sign indicates that the top of the ladder is moving upwards.</p>

Table 4 presents the responses of ChatGPT and Bard in computational questions. These AI models were not able to correctly answer the Prompts 1 and 2. In Prompt 1, they had different answers, but both were incorrect; while in Prompt 2, they had same answer but also incorrect. In Prompt 1, the function $y = \frac{1}{x^2}$ has an asymptote at $x = 0$ —for a function to be integrated, it must be continuous within the bounded intervals, in this case at $[-1, 1]$ —and that, the function violated this assumption.

Prompt 2 is a problem in related rates and the answer should be $\frac{3}{2} m/s$ as indicated in **Figure 1** below:

Using the Pythagorean Theorem, we have the relationship:

$$x^2 + y^2 = 10^2$$

We differentiate the equation with respect to time:

$$\begin{aligned} 2x \frac{dx}{dt} + 2y \frac{dy}{dt} &= 0 \\ \frac{dy}{dt} &= -\frac{x}{y} \frac{dx}{dt} \end{aligned}$$

If $x = 6$, we compute for y as follows:

$$\begin{aligned} x^2 + y^2 &= 10^2 \\ 36 + y^2 &= 100 \\ y &= 8; (y > 0) \end{aligned}$$

Note that because the ladder moves towards left, $\frac{dx}{dt} = -2 m/s$ relative to direction. Substituting the given values, we have:

$$\begin{aligned} \frac{dy}{dt} &= -\frac{x}{y} \frac{dx}{dt} \\ \frac{dy}{dt} &= -\frac{6}{8} (-2) \\ \frac{dy}{dt} &= \frac{3}{2} m/s \end{aligned}$$

Figure 1. Solution to Prompt 2.

It was notable that ChatGPT answered the Prompt 2 correctly on the second run of the chat prompt. This suggested that while it provided wrong answer initially, sometimes running the chat prompt again could give the right answer. This rise questions on how often ChatGPT and other AI models provide correct and wrong answers to exact same questions because this is a serious limitation in learning mathematics. As one student said, “what [AI] gives is wrong or incomplete” [Participant 9] explaining that relying in AI alone is not enough and one should “know the foundation.”

4.3. Programming education with AI-assisted learning

The implementation of AI-assisted teaching has demonstrated a highly impactful influence on the field of basic mathematics education and instructional methods^[51,52] but also has some limitations^[4,53,54]. Not all AI is flawed inherently, but it is only dependable in select areas and with specific methodologies^[53,54]. This explained why “...when it comes to calculus or physics that need to solve with numbers, I’m not usually using ChatGPT” [Participant 10] and that “it also cannot give specific information especially if you ask it to do mathematical problem solving” [Participant 1]. Hence, instructors and teachers have important role in managing different strategies that innovates critical thinking and assessment with emphasis on student-centered approach^[55–57]. One participant suggested that while AI models provided inaccurate results, this could be used as an activity where students are asked to detect accuracies in its response and make corrections on

them. As AIED model^[19] posited, it is important to develop a learning framework that widely consider the needs of students in the context of AI-assisted learning.

This study presented some remarkable limitations of commonly used AI models in learning mathematics. Some students used AI such as ChatGPT and Bard to solve for mathematical questions while others used them only for generating explanations. Although there were promising reinforcements in learning like explanations of mathematical processes, blindly relying to their answers without verifying its validity could be the future concerns of teachers.

5. Limitations

This study was concerned about the generalizability of the results especially following the research design used. The design was not enough to expand the results to other relevant fields. There was a need to extend the design, e.g., experimental study and longitudinal set-ups, to capture long-term and time-sensitive data. The design should also focus on the awareness, attitude, motivation, and effects of using AI to the academic success of students—several concepts that were not described in this study. Nevertheless, this study sufficiently described the scope of AI-assisted mathematics learning and how educational institutions could adapt to this academic direction.

6. Conclusion

Using AI models in learning mathematics has promising insights. AI models were powerful tools for students in answering word problems and computations. AI models e.g., ChatGPT can understand simple mathematical symbols like integrals, close intervals, and limit. Mathematics-oriented students often used these AI models in generating solutions, explanations, or proofs to mathematical statements. Notably, students were also aware of their limitations like wrong or inaccurate answers and methods. Sometimes, AI models are also able to detect their mistakes and change their answers when the student prompts them to do.

Future directions of using AI models in learning mathematics should be studied. This study raised some questions on the application of AI models. This study wanted to expand on several concepts specifically on how often AI models are able to detect their mistakes, how the use of AI models increases the motivation of students to learn, and how to model an AI that can be used in learning mathematics. These aspects of student-centered learning aspects could improve the productivity and competence of students in the field of mathematics and other applied areas.

Conflicts of interest

The author declares no conflict of interest.

References

1. Qiu Y, Pan J, Ishak NA. Effectiveness of artificial intelligence (AI) in improving pupils' deep learning in primary school mathematics teaching in Fujian province. *Computational Intelligence and Neuroscience* 2022; 2022: 1–10. doi: 10.1155/2022/1362996
2. Barroso C, Ganley CM, McGraw AL, et al. A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin* 2021; 147(2): 134–168. doi: 10.1037/bul0000307
3. Sherman BF, Wither DP. Mathematics anxiety and mathematics achievement. *Mathematics Education Research Journal* 2003; 15(2): 138–150. doi: 10.1007/bf03217375
4. Duhaylungsod AV, Chavez JV. ChatGPT and other AI users: Innovative and creative utilitarian value and mindset shift. *Journal of Namibian Studies* 2023; 33: 4367–4378. doi: 10.59670/jns.v33i.2791
5. Bishop CM. *Pattern Recognition and Machine Learning*. Springer; 2006.
6. LeCun Y, Bengio Y, Hinton G. Deep learning. *Nature* 2015; 521(7553): 436–444. doi: 10.1038/nature14539
7. MacKay DJ. *Information Theory, Inference and Learning Algorithms*. Cambridge university press; 2003.

8. Raghu M, Schmidt E. A survey of deep learning for scientific discovery. *arXiv* 2020; arXiv:2003.11755. doi: 10.48550/arXiv.2003.11755
9. Wagner AZ. Constructions in combinatorics via neural networks. *arXiv* 2021; arXiv:2104.14516. doi: 10.48550/arXiv.2104.14516
10. Peifer D, Stillman M, Halpern-Leistner D. Learning selection strategies in Buchberger's algorithm. *arXiv* 2020; arXiv:2005.01917. doi: 10.48550/arXiv.2005.01917
11. Lample G, Charton F. Deep learning for symbolic mathematics. *arXiv* 2019; arXiv:1912.01412. doi: 10.48550/arXiv.1912.01412
12. He YH. Machine-learning mathematical structures. *International Journal of Data Science in the Mathematical Sciences* 2023; 1(1): 23–47. doi: 10.1142/S2810939222500010
13. Chavez JV, Lamorinas DD, Ceneciro CC. Message patterns of online gender-based humor, discriminatory practices, biases, stereotyping, and disempowering tools through discourse analysis. *Forum for Linguistic Studies* 2023; 5(2): 1535. doi: 10.59400/fls.v5i2.1535
14. The World Bank. In Ecuador, artificial intelligence makes learning math easier. Available online: <https://www.worldbank.org/en/news/feature/2022/02/10/en-ecuador-aprender-matematicas-es-mas-facil-con-inteligencia-artificial-nivelacion-remediacion-academica> (accessed on 10 July 2023).
15. Moore K. Using ChatGPT in math lesson planning. Available online: <https://www.edutopia.org/article/using-chatgpt-plan-high-school-math-lessons/> (accessed on 10 July 2023).
16. Thorp HH. ChatGPT is fun, but not an author. *Science* 2023; 379(6630): 313–313. doi: 10.1126/science.adg7879
17. Baidoo-Anu D, Owusu Ansah L. Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning. *Journal of AI* 2023; 7(1): 52–62.
18. Firat M. What ChatGPT means for universities: Perceptions of scholars and students. *Journal of Applied Learning and Teaching* 2023; 6(1): 1–22. doi: 10.37074/jalt.2023.6.1.22
19. Ouyang F, Jiao P. Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence* 2021; 2: 100020. doi: 10.1016/j.caeai.2021.100020
20. Greeno JG, Collins AM, Resnick LB. Cognition and learning. In: *Handbook of Educational Psychology*. Routledge; 1996.
21. Schommer M. Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology* 1990; 82(3): 498–504. doi: 10.1037/0022-0663.82.3.498
22. Bandura A. *Social Foundations of Thought and Action*. Prentice Hall; 1985.
23. Liu CH, Matthews R. Vygotsky's philosophy: Constructivism and its criticisms examined. *International Education Journal* 2005; 6(3): 386–399.
24. Bandura A. Toward a psychology of human agency. *Perspectives on Psychological Science* 2006; 1(2): 164–180. doi: 10.1111/j.1745-6916.2006.00011.x
25. Riedl MO. Human-centered artificial intelligence and machine learning. *Human Behavior and Emerging Technologies* 2019; 1(1): 33–36. doi: 10.1002/hbe2.117
26. Shneiderman B. Human-centered artificial intelligence: Reliable, safe & trustworthy. *International Journal of Human-Computer Interaction* 2020; 36(6): 495–504. doi: 10.1080/10447318.2020.1741118
27. Deeva G, Bogdanova D, Serral E, et al. A review of automated feedback systems for learners: Classification framework, challenges and opportunities. *Computers & Education* 2021; 162: 104094. doi: 10.1016/j.compedu.2020.104094
28. Hwang GJ, Xie H, Wah BW, Gašević D. Vision, challenges, roles and research issues of artificial intelligence in education. *Computers and Education: Artificial Intelligence* 2020; 1: 100001. doi: 10.1016/j.caeai.2020.100001
29. Kawakami A, Guerdan L, Cheng Y, et al. Towards a learner-centered explainable AI: Lessons from the learning sciences. *arXiv* 2022; arXiv:2212.05588. doi: 10.48550/arXiv.2212.05588
30. Lee D, Huh Y, Lin CY, Reigeluth CM. Technology functions for personalized learning in learner-centered schools. *Educational Technology Research and Development* 2018; 66: 1269–1302. doi: 10.1007/s11423-018-9615-9
31. Singh K. *Quantitative Social Research Methods*. SAGE; 2007. doi: 10.4135/9789351507741
32. Chavez JV. Narratives of bilingual parents on the real-life use of English language: Materials for English language teaching curriculum. *Arab World English Journal* 2022; 13(3): 325–338. doi: 10.24093/awej/vol13no3.21
33. Calaro MF, Vicente MB, Chavez JV, et al. Marketing campaigns leading to the purchase of accommodation products: A content analysis. *Journal of Namibian Studies* 2023; 33: 4221–4236. doi: 10.59670/jns.v33i.2696
34. Ceneciro CC, Estoque MR, Chavez JV. Analysis of debate skills to the learners' confidence and anxiety in the use of the English language in academic engagements. *Journal of Namibian Studies* 2023; 33: 4544–4569. doi: 10.59670/jns.v33i.2812
35. Frost J. Purposive sampling: Definition & examples. Available online: <https://statisticsbyjim.com/basics/purposive-sampling/> (accessed on 8 July 2023).

36. Esterberg KG. *Qualitative Methods in Social Research*. McGraw-Hill Humanities/Social Sciences/Languages; 2001.
37. Crosley J. What (exactly) is thematic analysis? Available online: <https://gradcoach.com/what-is-thematic-analysis/> (accessed on 8 July 2023).
38. Duan P, Jia Y, Liang L, et al. Space-reserved cooperative caching in 5G heterogeneous networks for industrial IoT. *IEEE Transactions on Industrial Informatics* 2018; 14(6): 2715–2724. doi: 10.1109/TII.2018.2794615
39. Etcuban JO, Campanilla BS, Horteza AD. The use of Mathcad in the achievement of education students in teaching College Algebra in a university. *International Electronic Journal of Mathematics Education* 2019; 14(2): 341–351. doi: 10.29333/iejme/5718
40. Kilpatrick J. History of research in mathematics education. In: *Encyclopedia of Mathematics Education*. Springer, Dordrecht; 2014. pp. 349–354.
41. McCulloch AW, Hollebrands K, Lee H, et al. Factors that influence secondary mathematics teachers' integration of technology in mathematics lessons. *Computers & Education* 2018; 123: 26–40. doi: 10.1016/j.compedu.2018.04.008
42. Swai CZ, Glanfield F. Teacher-led professional learning in Tanzania: Perspectives of mathematics teacher leaders. *Global Education Review* 2018; 5(3): 183–195.
43. Wardat Y, Tashtoush MA, AlAli R, Jarrah AM. ChatGPT: A revolutionary tool for teaching and learning mathematics. *Eurasia Journal of Mathematics, Science and Technology Education* 2023; 19(7): em2286. doi: 10.29333/ejmste/13272
44. Tack A, Piech C. The AI teacher test: Measuring the pedagogical ability of blender and GPT-3 in educational dialogues. *arXiv* 2022; arXiv:2205.07540. doi: 10.48550/arXiv.2205.07540
45. Cunningham-Nelson S, Baktashmotlagh M, Boles W. Visualizing student opinion through text analysis. *IEEE Transactions on Education* 2019; 62(4): 305–311. doi: 10.1109/TE.2019.2924385
46. Li L, Ma Z, Fan L, et al. ChatGPT in education: A discourse analysis of worries and concerns on social media. *arXiv* 2023; arXiv:2305.02201. doi: 10.48550/arXiv.2305.02201
47. Dyer E, Gur-Ari G. Minerva: Solving quantitative reasoning problems with language models. Available online: <https://ai.googleblog.com/2022/06/minerva-solving-quantitative-reasoning.html> (accessed on 9 July 2023).
48. Alobaidi OG, Crockett KA, O'Shea JD, Jarad TM. Abdullah: An intelligent arabic conversational tutoring system for modern islamic education. In: *Proceedings of the World Congress on Engineering*; 3–5 July 2013; London, UK.
49. Lauesen S. *User Interface Design: A Software Engineering Perspective*. Addison-Wesley; 2004.
50. Mageira K, Pittou D, Papasalouros A, et al. Educational AI Chatbots for content and language integrated learning. *Applied Sciences* 2022; 12(7): 3239. doi: 10.3390/app12073239
51. bin Mohamed MZ, Hidayat R, binti Suhaizi NN, et al. Artificial intelligence in mathematics education: A systematic literature review. *International Electronic Journal of Mathematics Education* 2022; 17(3): em0694. doi: 10.29333/iejme/12132
52. Wu R. RETRACTED: Visualization of basic mathematics teaching based on artificial intelligence. *Journal of Physics: Conference Series* 2021; 1992(4): 042042. doi: 10.1088/1742-6596/1992/4/042042
53. University of Cambridge. Mathematical paradox demonstrates the limits of AI. Available online: <https://www.cam.ac.uk/research/news/mathematical-paradox-demonstrates-the-limits-of-ai> (accessed on 9 July 2023).
54. Colbrook MJ, Antun V, Hansen AC. The difficulty of computing stable and accurate neural networks: On the barriers of deep learning and Smale's 18th problem. *Proceedings of the National Academy of Sciences* 2021; 119(12): e2107151119. doi: 10.1073/pnas.2107151119
55. Chavez JV. Assessing online academic integrity and humanized teaching in Zamboanga Peninsula Polytechnic State University. *Journal of Multidisciplinary in Social Sciences* 2023; 19(1): 9–17.
56. Chavez J, Lamorinas DD. Reconfiguring assessment practices and strategies in online education during the pandemic. *International Journal of Assessment Tools in Education* 2023; 10(1): 160–174. doi: 10.21449/ijate.1094589
57. Chen Z. Artificial intelligence evaluation for mathematics teaching in colleges under the guidance of wireless network. *Mobile Information Systems* 2022; 2022; 3201004. doi: 10.1155/2022/3201004